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163

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

KUNDAH PROJECT NUMBER

VOL. X NO. 4 APRIL, 1960 RUPEES FOUR

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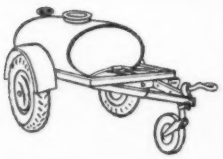
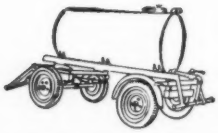
KUNDAH PROJECT POWER HOUSE, NO. I, MADRAS



WATER TRAILER

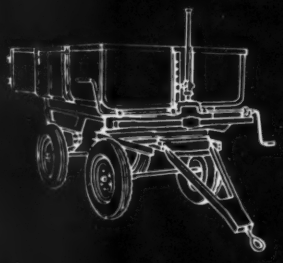
ROAD MASTER TANK TRAILER



REX

ROAD BUILDING EQUIPMENT

TIPPER TRAILER



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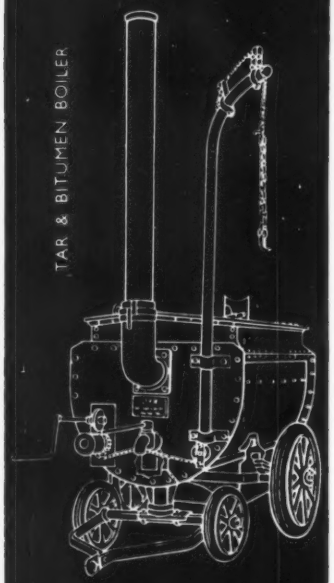

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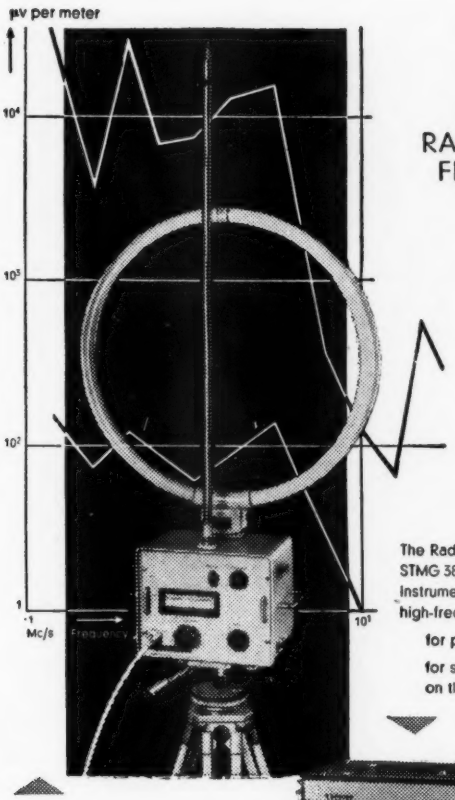

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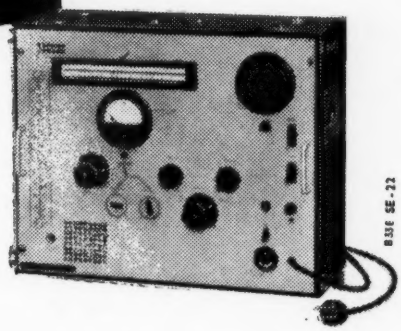
for precise individual testing

for speedy series measurements on the production line



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on HF and ultra-sonic generators

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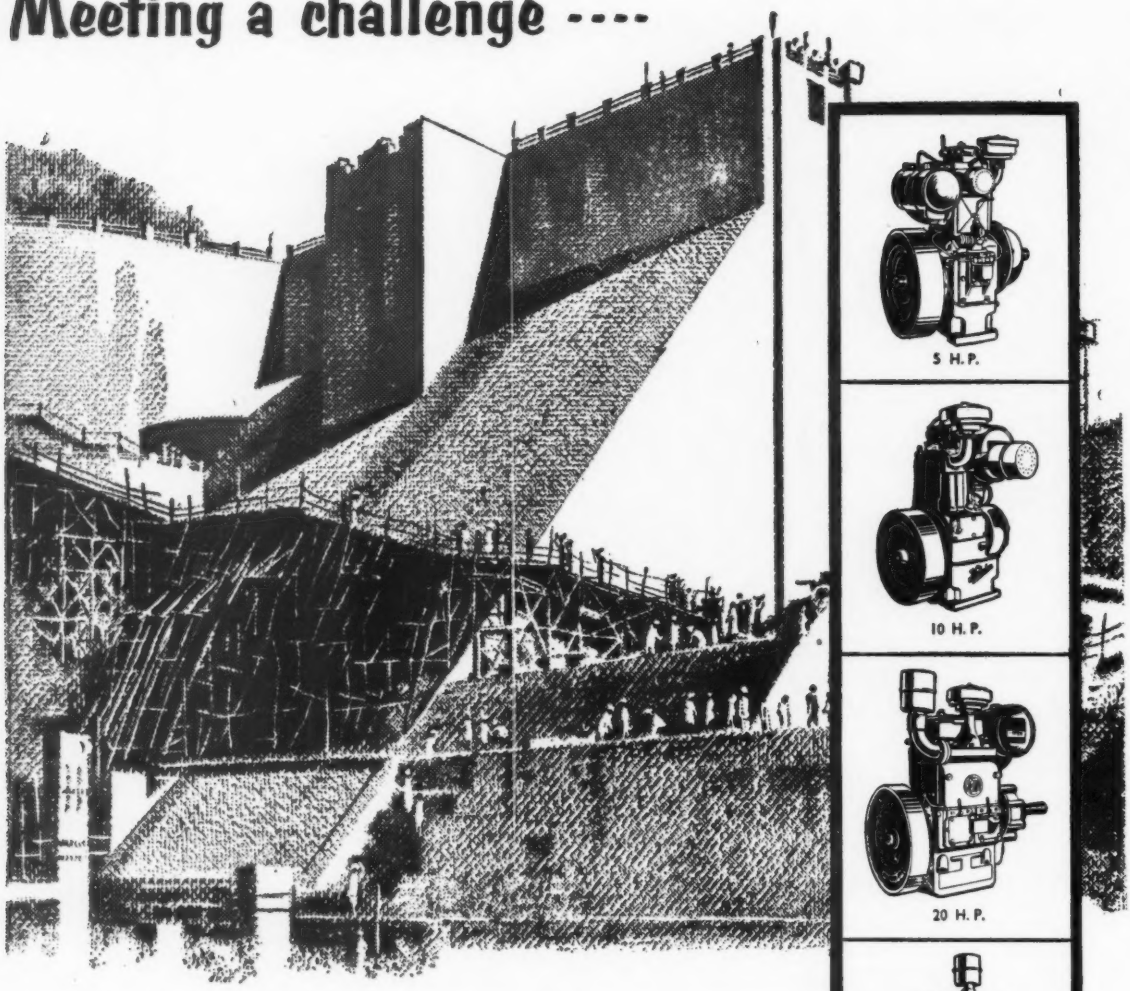

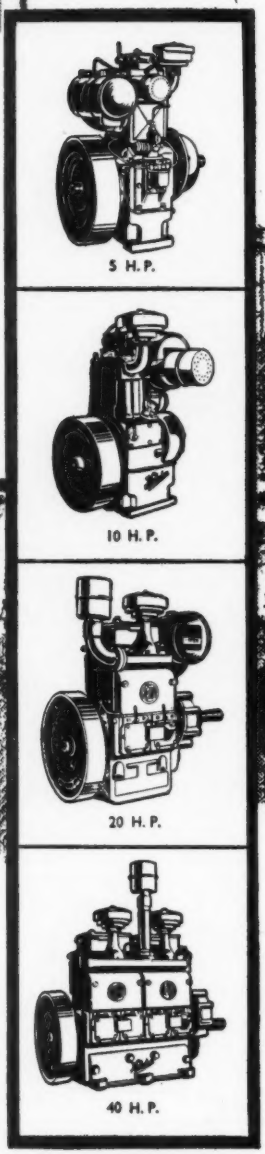

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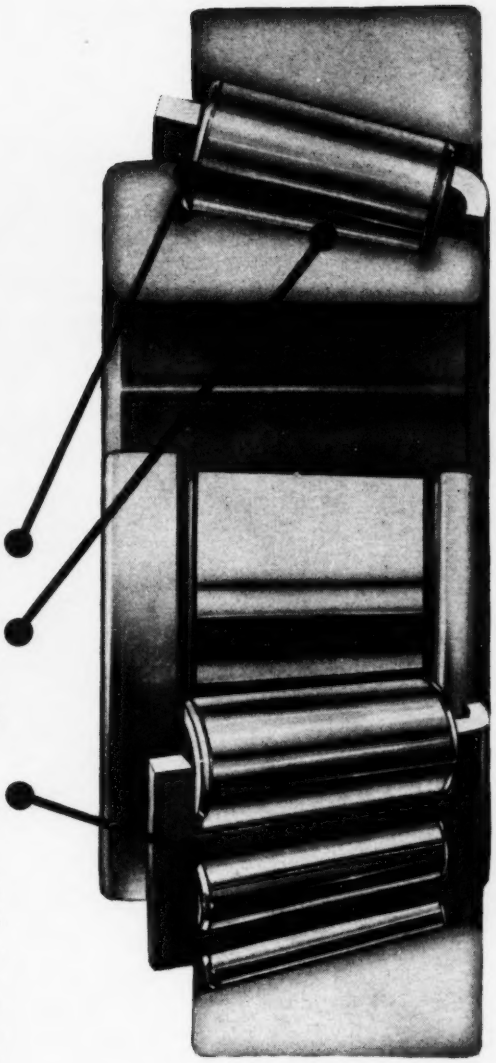

1. TAPERED DESIGN enables Timken tapered roller bearings to take any combination of radial and thrust loads.

2. POSITIVE ALIGNMENT. Wide-area contact between rollers and cone rib keeps Timken bearings in positive alignment.

3. FULL-LINE CONTACT between rollers and races gives Timken bearings extra load-carrying capacity.

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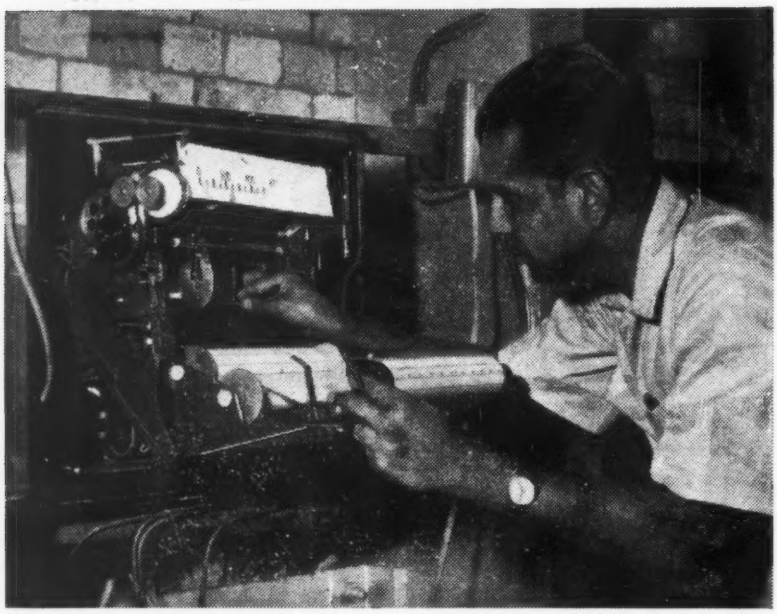

GETTING READY FOR STEELMAKING

A skilled Indian technician makes adjustments to the Temperature Recorder for an Open Hearth Furnace in the Steel Melting Shop at Durgapur Steelworks.

The commissioning of the first Open Hearth Furnaces and the start of steel production at Durgapur will be another step forward in this great indo-British enterprise.

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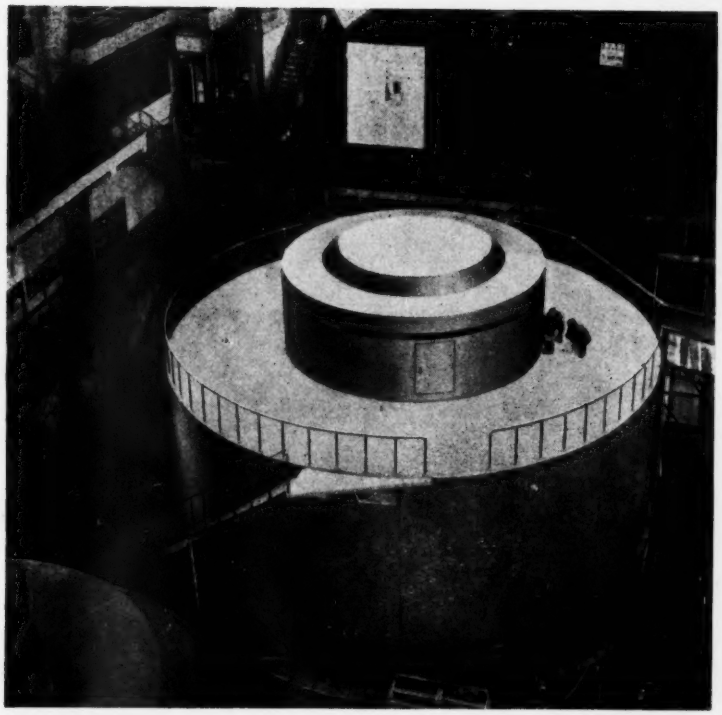

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Just finished !! Toshiba is proud to announce that it has just completed fabrication of the second largest water wheel generator in the world. This generator will be used to generate 133,000kVA when it is installed in Japan's new Okutadami Power Station. This generator, and all the products made by Toshiba from gigantic power plants to tiny transistors, are the fruits of more than three-quarters of a century of experience in the manufacture of everything electrical. Toshiba is constantly contributing to better living for you!

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L-47
L-57
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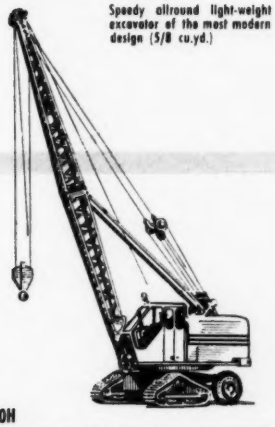
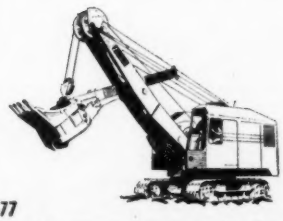
- excavators designed for tough digging.
They may be equipped with easily exchangeable attachments for all kinds of digging and loading and with special attachments for crane work, pile driving, etc.

L-47
Speedy allround light-weight excavator of the most modern design (5/8 cu.yd.)





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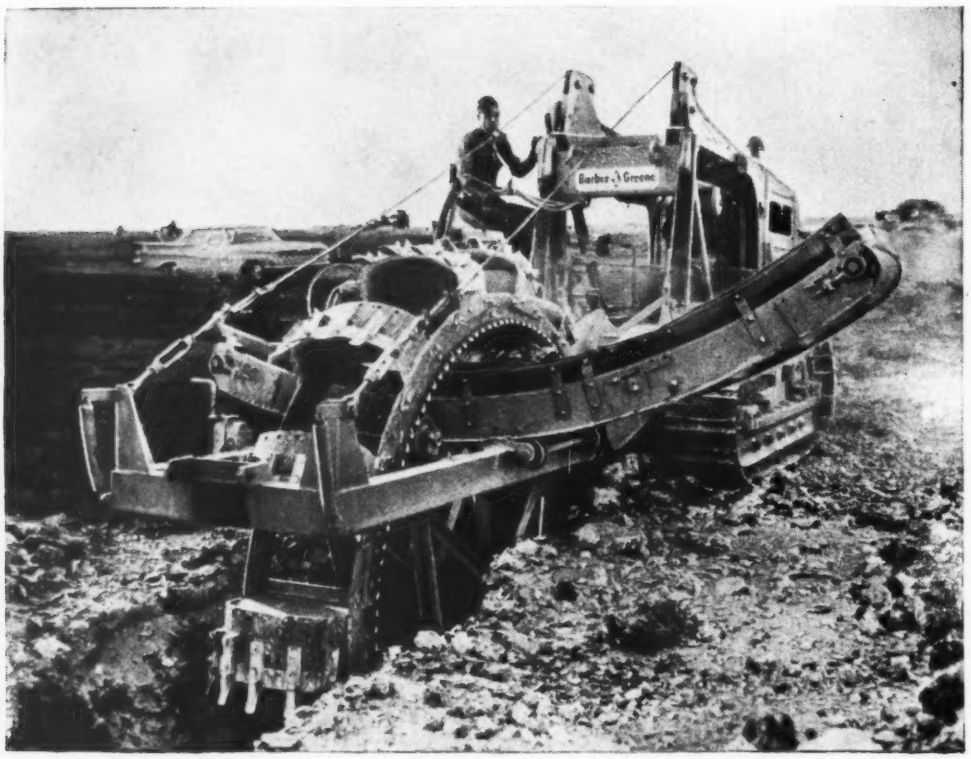

New Barber-Greene 7' Wheel Ditcher crowds through rugged caliche in Texas—at speeds many times greater than ladder ditchers or back hoes working in the area. Write for details.

NEW 7-FOOT WHEEL DITCHER

digs more ditch . . . deeper ditch than any machine in its size range

Barber-Greene's new 7' wheel ditcher offers more ditch for the money than ever before. It digs deeper than any wheel ditcher in its size and price range.

Check these advantages:

Advanced design. Greater manoeuvrability—smaller, more compact than other wheel ditchers digging to 7'. The only wheel ditcher available with point of balance at centre of tracks.

Costs less to operate—exclusive Barber-Greene design advantages add up to more ditch per day with less maintenance . . . less down time . . . less wear.

Full range of crowding speeds—exclusive Barber-Greene Hydra-Crowd provides infinite range of crowding speeds . . . permits top digging capacity in all conditions.

Easier to operate—full hydraulic controls within easy reach means less operator fatigue . . . easiest steering . . . greater accuracy.

All-hydraulic spoil conveyor—10' variable-speed conveyor loads directly into trucks . . . handles spoil at speeds to 640 fpm. Folds to 8'. Rubber impact rollers reduce belt wear, eliminate material build-up beneath belt.

New compact size—only 26'5" long, 8'6" high in operating position. 7' wide across tracks.

Write for information on the newest ditcher in the line of advanced design

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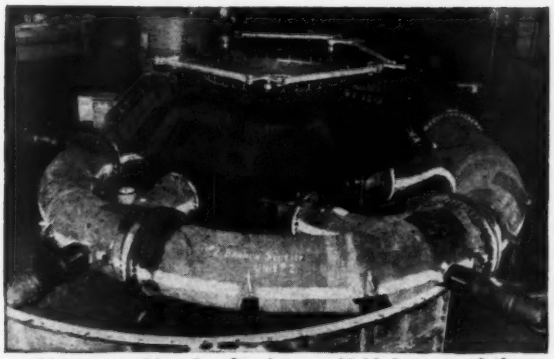
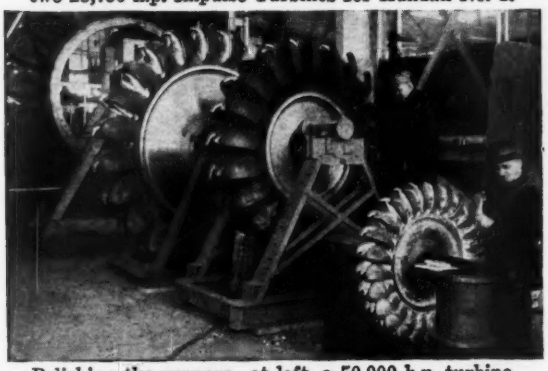
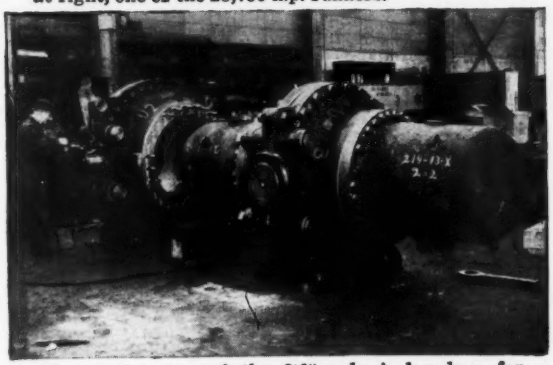


Shop assembly of a five-jet manifold for one of the two 28,750 h.p. Impulse Turbines for Kundah No. 1.



Polishing the runners—at left, a 50,000 h.p. turbine, at right, one of the 28,750 h.p. runners.



Shop-testing one of the 2'6" spherical valves for Kundah No. 2 at a pressure of 2,140 psi.

"IT MAKES LIGHT WHERE THERE WAS DARK."

This remark was made by one of the workers on the Kundah Hydro-Electric Project. It is a tribute to the planners of this development, and it was particularly appreciated by the men at Dominion Engineering, designers and manufacturers of the impulse turbines and spherical valves installed at both stations.

Equipment supplied by Dominion Engineering includes:

2 Dominion Impulse Turbines of 28,750 hp each — under a head of 1,186 ft.

4 Dominion Impulse Turbines of 50,000 hp each — under a head of 2,470 ft.

Spherical Shut-Off Valves for each Turbine.

Manifolds and ancillary equipment.

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COMPANY LIMITED
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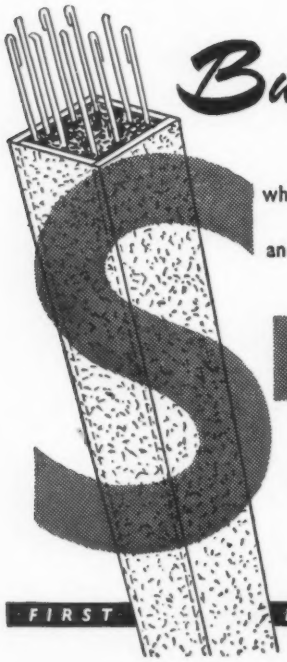

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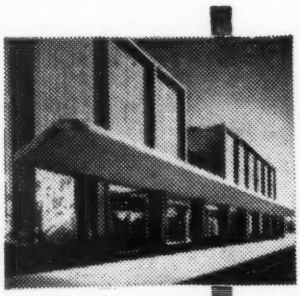

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FIRST IN THE FIELD AND STILL LEADING

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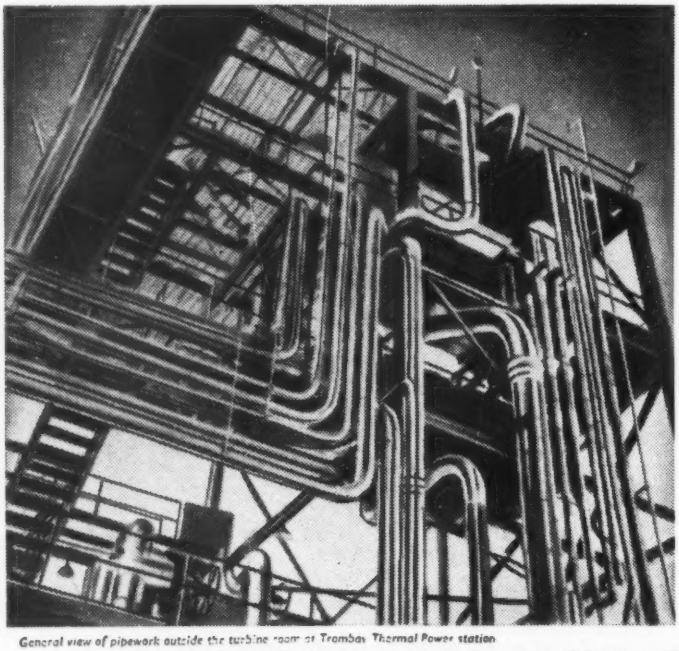

General view of pipework outside the turbine room at Trombay Thermal Power station

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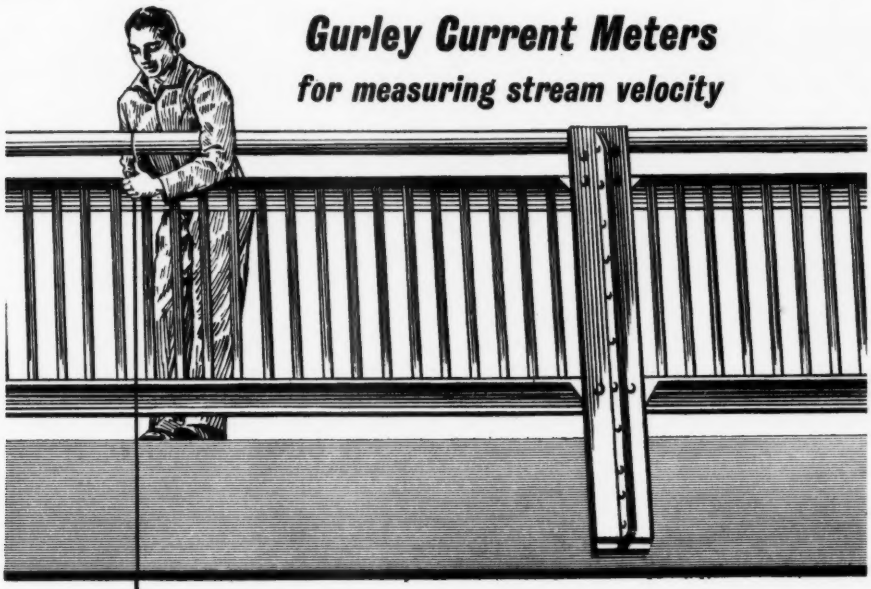
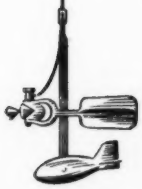


Gurley Current Meters
for measuring stream velocity



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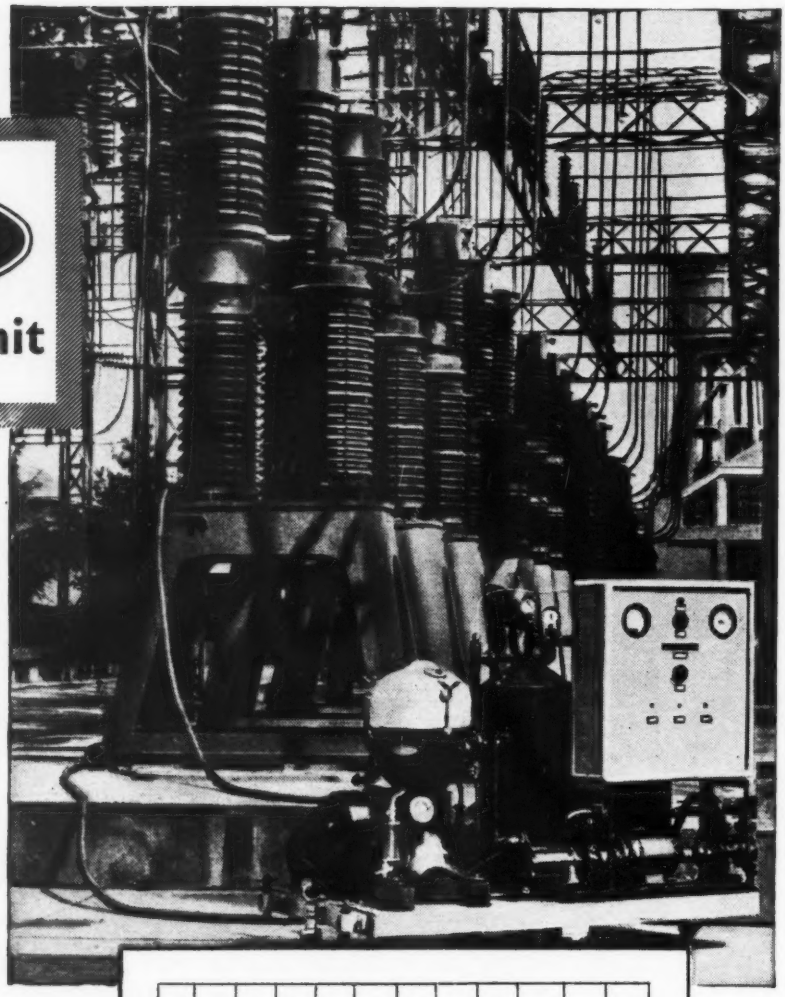
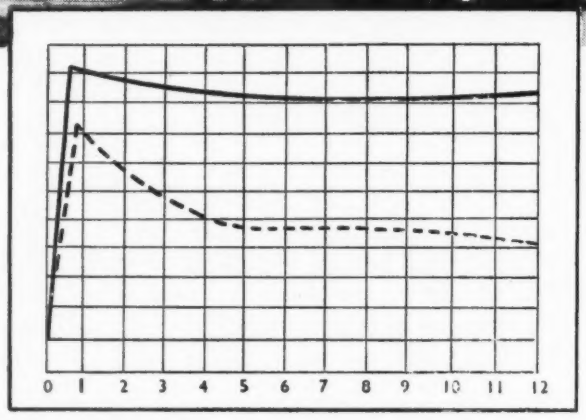
SISTA'S-EE-67

DE LAVAL

High Vacuum Unit

simple and positive method of oil purification in transformers





An example of comparative test with two similar transformers operated under the same conditions. The oil in transformer No. 1 was treated by a DE LAVAL High-Vacuum Unit, whereas the oil in No. 2 was purified by means of a filter press. In transformer No. 2 the dielectric strength of the oil rapidly fell off, because the oil was saturated with dissolved moisture, whereas the dry oil in transformer No. 1 retained its high dielectric strength even after 12 weeks' service, when the test was discontinued.

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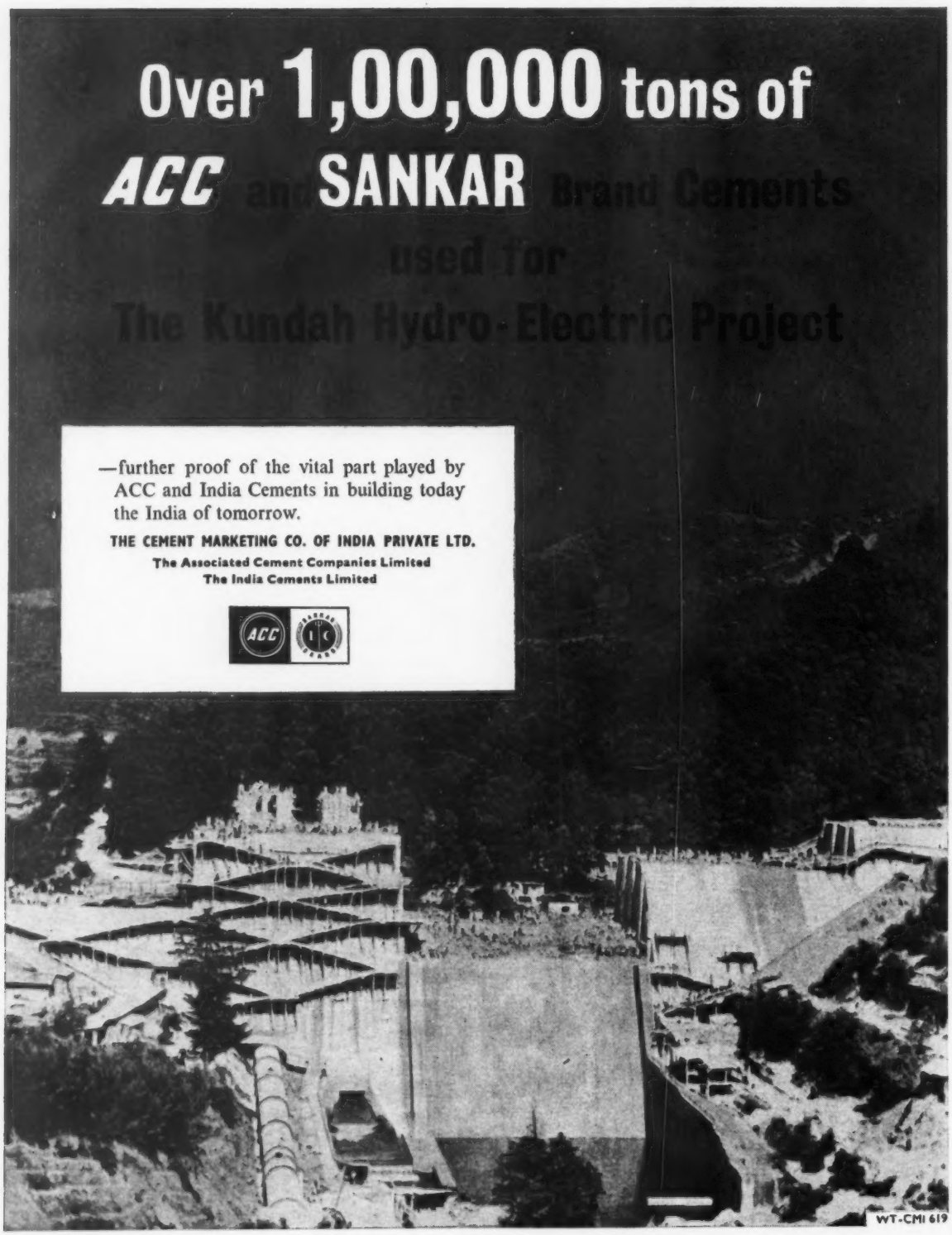
Over 1,00,000 tons of
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THE CEMENT MARKETING CO. OF INDIA PRIVATE LTD.
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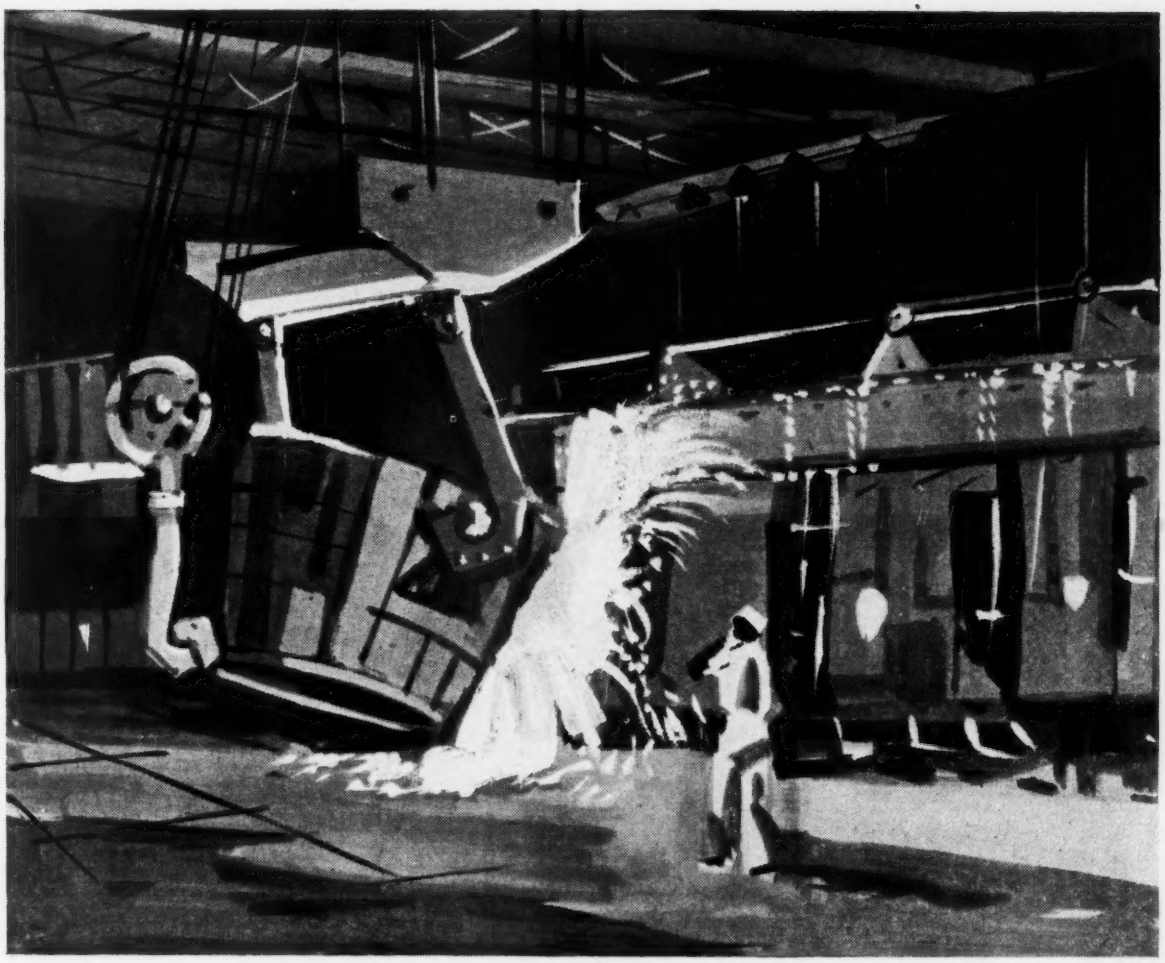

Charging Giant Open Hearth Furnace at the Burnpur works of The Indian Iron & Steel Company Limited

The great ladle tilts, disgorging its cargo of molten metal into the open hearth. Here is the last stage in the ordeal by fire which transforms iron into the master metal—Steel.

STEEL, the starting point of all industries.

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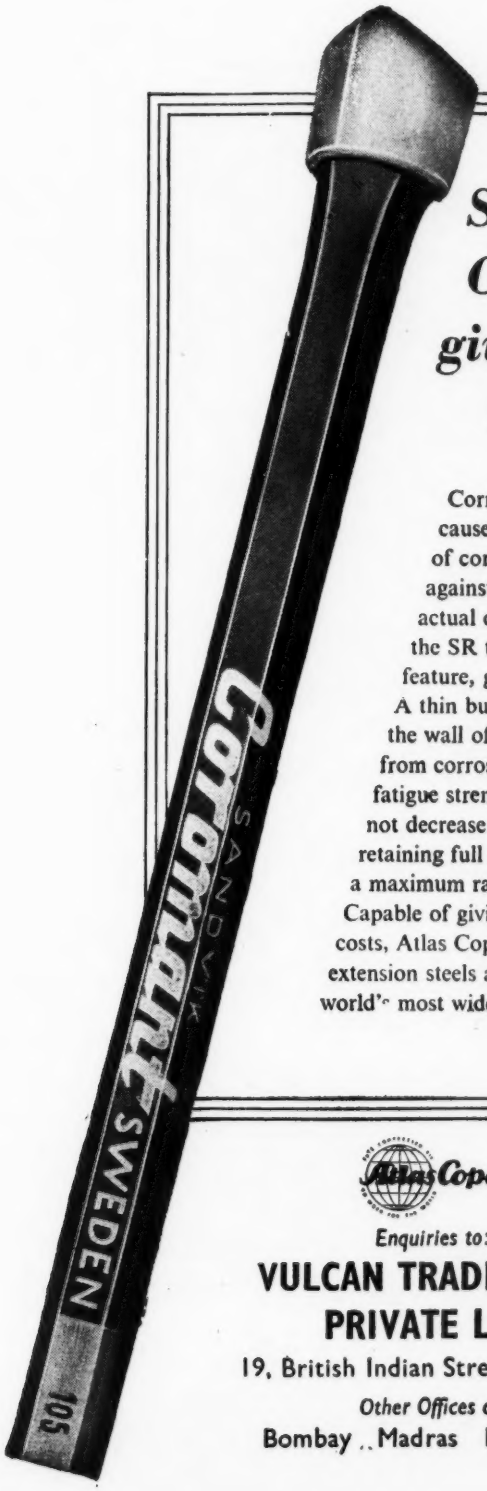

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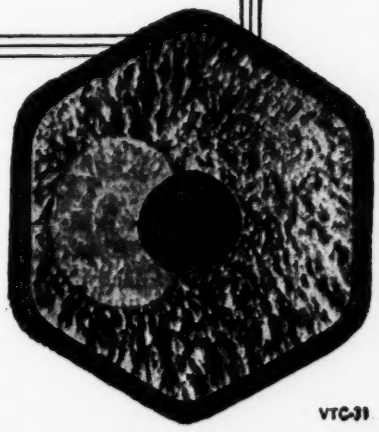

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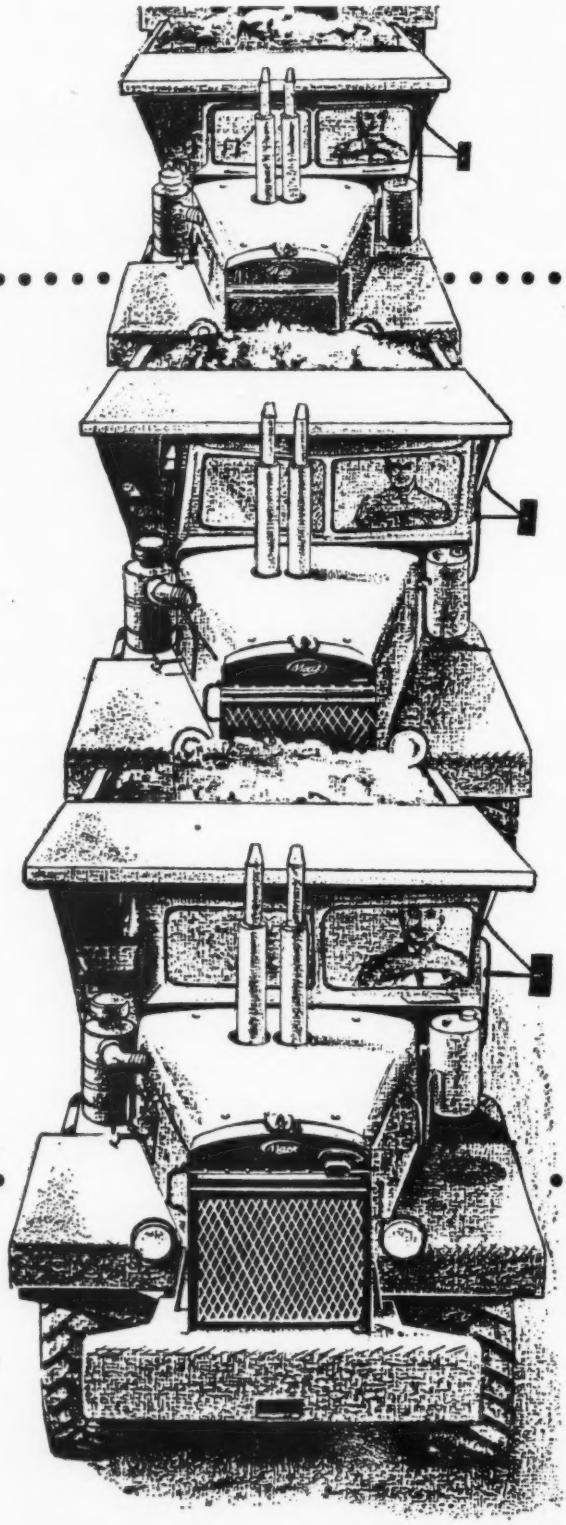

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : K. K. Sinha — P. K. Menon : Mg. Editor

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Kundah Project Number

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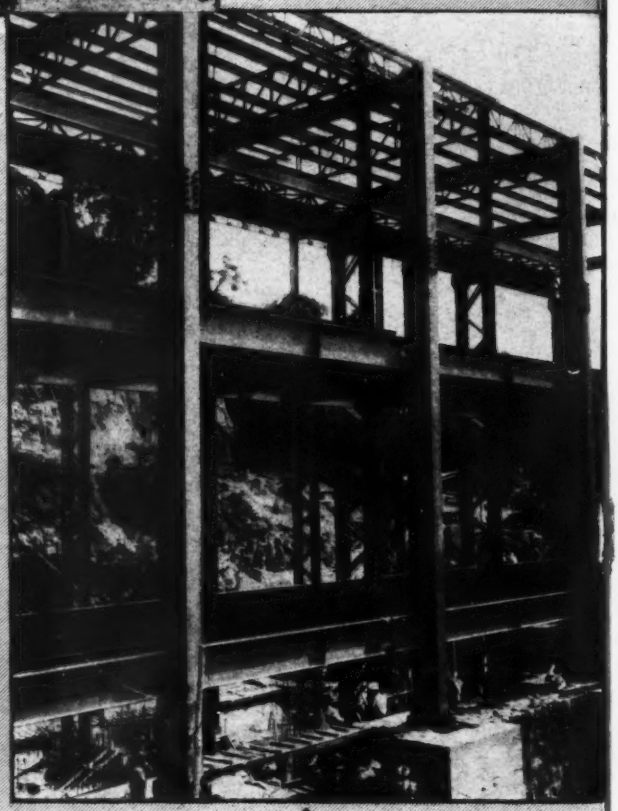

A view of the Periyar Power House under construction by S. A. E. (Supply and Erection)

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Messages

It is a pleasure for me to send you my warmest congratulations and best wishes on this occasion. At this ceremony in which your distinguished Prime Minister is participating, you are recording another stage in the development of the Kundah hydro electric power project which India and Canada are building under the Colombo Plan. I am sure that this event will bring a sense of deep satisfaction to all of those who have had part in the project. May I say that we in Canada share this feeling with you. I am sure that when the Project is in full operation it will yield many practical benefits to the people of South India.

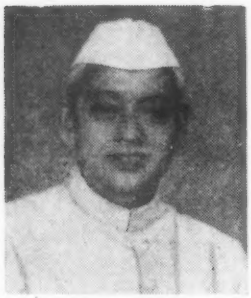
This project will also symbolise the cooperative nature of the Colombo Plan. It is a matter of gratification to all Canadians that engineers, technicians and experts from our two countries have worked closely together in friendship and understanding, and have brought this impressive project to its final stages. I am confident that these bonds of mutual understanding will make a lasting contribution to the deep and close association which is continuing to grow between our two countries.

I join with your Prime Minister in congratulating all those, both in India and Canada, who have participated in the building of the Kundah hydro electric power project. I wish you well in the future economic development of your country to which this project will, I am sure, make a very significant contribution".

JOHN G. DIEFENBAKER
Prime Minister of Canada

I send my good wishes to the Special Number of the Indian Journal of Power and River Valley Development which is devoted to the Kundah Project in Madras. This project is of importance and I am glad that its various aspects are going to be brought before the public. Indeed, in all our projects big and small, we should endeavour to gain the understanding and cooperation of the public. It is with this cooperation only that full success comes.

JAWAHARLAL NEHRU
Prime Minister of India



I am very happy to know that the Kundah Hydro Electric Scheme will be inaugurated shortly. The scheme estimated to cost about Rs. 35 crores is the biggest of the schemes so far undertaken in Madras State. The Government of Canada have to be thanked gratefully for giving aid to the extent of about Rs. 12.5 crores for the execution of this scheme.

The inauguration of the Kundah Scheme is an important event in this State and this will go a long way in supplying much needed power for domestic and industrial purposes. Our engineers deserve all praise for the good work done in executing the scheme according to schedule.

I send my best wishes for the success of the scheme.

BISNURAM MEDHI
Governor of Madras

It is now for more than a decade that Madras has been suffering from electricity shortage. Amongst the schemes that have been taken up under the Second Five Year Plan to meet the power hunger of the State, the Kundah Project, being executed with Canadian assistance, is the most important and the biggest. I am glad that the Indian Journal of Power and River Valley Development is bringing out a special issue for this project.

HAFIZ MOHD. IBRAHIM
Minister for Irrigation and Power
Government of India

The Kundah Project, in the Nilgiris, is the largest hydro-electric scheme so far undertaken in Madras State. The implementation of this Project owes much to the friendly gesture of the Canadian Government in providing financial aid for the purchase of plant, machinery and equipment under the Colombo Plan. The work is proceeding apace and, on completion, the Project will add 180 MW of power to the Madras power system which, for more than a decade, has been experiencing severe power shortage.

I am happy to learn that a special issue of the Indian Journal of Power and River Valley Development is being brought out for this Project.

J. L. HATHI
Dy. Minister for Irrigation and Power
Government of India

We Canadians have been happy to have been associated with India in particular with the Madras State Electricity Board in the construction of the Kundah Project in the Nilgiris Hill. As you no doubt know, after Norway Canada has the largest per capita consumption of electricity in the world, and with our abundant water power resources amounting to many millions of horse power, our engineers have had a great deal of experience in this field. This experience we have been happy to share with our Indian friends. It is my hope, and I know it is also the hope of my Government that projects such as Kundah will go a long way to meeting the aspirations of the Indian people for a better life for India's farmers, manufacturers, and workers.

C. A. RONNING
High Commissioner for Canada in India

I am happy to learn that the Indian Journal of Power and River Valley Development is bringing out a Special Number denoted to the Kundah Hydro-electric Project which will be the largest Hydro-electric Project in the Madras State so far. The commissioning of this Project with 180 MW installed power plant in the very near future will mark another milestone in the progress of power development in India and will considerably help in meeting the acute power shortage in southern area. I have no doubt that the series of the articles proposed to be published in this Special Number will be of great interest to your readers and particularly to engineers in this country and abroad. The information so published will be of immense value in understanding the technical as well as constructional features of this Project and may also bring to light the difficulties that confronted the engineers in the course of construction of this Project and how they overcame these to achieve a speedy completion.

M. HAYATH
Chairman,
Central Water and Power Commission

Messages from Canadian Engineers

What perhaps impressed me most about the project was the organisation which has been set up to direct a labour force of some 10,000 persons constructing this vast undertaking. What you and your engineers are doing at Kundah with the minimum amount of mechanisation is something I feel is worthy of study by any western engineers or contractors interested in development work in your country.

During my two visits to Madras I have paid tribute to the engineers of the Madras State Electricity Board for their ability to plan, execute, maintain and operate hydro electric plants. The evidence of your ability in this field is there for all to see. While I was impressed with the meticulous work that went into all phases of the project—roads, housing, tunnels, dams and power houses—I was particularly impressd with the excellency of the masonry work which I am quite certain cannot be bettered in any part of the world.

To me it was an inspiration to find the labour force working without benefit of ballyhoo which accompanies this kind of an operation in other parts of the world. There is no compulsion, no mass meetings, no parades, all is done quietly but relentlessly. What your people achieved manually in a day is unbelievable to western eyes accustomed to fully mechanised operations.

To the men, women and children who are building Kundah, I pay tribute to a job well done, a job which will raise the standard of living not alone for themselves, but for generations to come. These are the people who are building India and work, to my mind, is the only answer to population pressures in developing countries.

F. E. PRATT.
Chief, Capital Projects,
Economic and Technical Assistance Branch
Department of Trade and Commerce,
Ottawa—4, Canada.

* * *

In November 1955 Mr. Sexton and I arrived in Madras for the Colombo Plan Administration of Canada to study the Kundah Project. Mr. V. P. Appadurai, Chief Engineer for Electricity, Madras State Electricity, Board, took us to the site and explained what he had in mind. He also explained how urgently the Kundah power was required for the growing needs of the State of Madras.

At that time there was nothing at Kundah but green hills and valleys, and mountain streams running in steep rocky gorges and down to the plain below.

We reported to the Colombo Plan Administration on what we had seen, and after consideration the Canadian Govt. decided they would like to help with this project. So they offered to contribute all the pipes and valves and hydraulic and electrical equipment, and towers and conductors for the transmission line to Madras, and certain construction equipment. The dams and tunnels and other construction work and the design and administration of the project as a whole would be under the direction of Mr. Appadurai.

Since then the work has gone ahead under his direction with Canada helping to the extent that it could, and now the great masonry barricades are rising across the valleys, stone on stone, tier on tier with infinite toil and care, and the mountain streams are filling the new lakes and running through the tunnels that have been carved out of the rock and down through the steel pipes to the power houses far below and driving the generators, and sending their power out all over the State of Madras.

This project has come into being because two sister nations on the opposite sides of the earth were willing to work together for the common good. It is a monument to the good that can be created when people work together as friends.

But the credit for the conception and design of the project, and for forcing it through to completion in all its far flung complexity goes to Mr. Appadurai and his staff, and I should like to record my respect for them and my admiration for the work they have done.

D. STAIRS,
Vice-President,
Montreal Engineering Co., Ltd.,
Montreal, Canada

* * *

When I visited Kundah first, in November 1956, only 4 months after the inaugural formalities in June, I was greatly impressed with the organisation developed during that brief period and the remarkable progress in construction of roads and buildings and the extent of the excavation and auxiliary work completed. This impression of remarkable organisation and achievement has only been enhanced by the subsequent visits in 1958 and 1959. Each time I see Kundah, the progress since the last visit has been amazing.

To me the most unusual features of the project are the efficient organisation, the concerted drive of the whole working force and the masterful and logical use of traditional methods of construction which appear to me to compare very favourably with some other similar projects which have been highly mechanized.

The advantage of maintaining high employment in the area and avoiding unnecessary expenditure of

foreign exchange are obvious but perhaps a greater significance might be attributed to the satisfaction of accomplishment with so much of your local resources.

The Canadians who have lent some assistance to this project are proud of their association with their Indian counterparts and of their successful joint endeavour. This power development is a true representation of what India can do with cooperation of Commonwealth partners in a joint effort to build the basic foundation of the economy.

Mr. R. G. Johnson and Mr. John Stirling join me in extending congratulations on the occasion of your successful completion of this project.

SHELDON ROSS
Project Engineer, Foreign Projects Divn
Economic & Technical Assistance Branch,
Department of Trade and Commerce,
Ottawa—4, Canada

* * *

Montreal Engineering Company entered the engineering field in India reluctantly, at a time when such services in Canada were at a premium. They did so to assist the Canadian Govt. to perform a service for a sister nation through the Colombo Aid Plan. Our engineers were perhaps a little apprehensive about accepting assignments so far away in a land unknown to them when times were good at home. Many felt they were passing up opportunities; that they would be by-passed by prolonged absence from our rapidly growing nation. Possibly there was an element of truth in their fears. However, they now fully admit they have gained much more by the experience than they could possibly have foreseen.

They found the Indian administration pleasant and cooperative, the engineers progressive and helpful and the Indian people themselves warm and friendly. Strangely enough they found the Indian engineer probably more formal than themselves. We canadian engineers suffer a little from a lack of ability to express ourselves and the many little formal gatherings of engineers at the end of a day's work rather surprised us but, on the other hand, they were enjoyed and polished up our public speaking abilities.

We could not help but be impressed by the well preserved symbols of your ancient civilization—and the obvious pride with which your people showed them to us. It underlined how young our own country is and how few and far apart are our historic monuments.

We were conscious too of many of your problems —particularly the difficulties of your huge population. In the streets and villages on an afternoon drive we could see almost as many people as there are in the whole of Canada. Fortunately for us visitors the Kundah Project is located in the interior of the State and to visit it one has the opportuntiy of seeing much of Madras. The Nilgiri hills are beautiful, reminiscent of Canada's rugged west. The plains are probably hotter and certainly more humid than ours but many of you who have stayed in eastern Canada have found a similar uncomfortably hot summer.

As for the Kundah project itself, Montreal Engineering Co. are as proud of it as you yourselves are—and rightly so. The project is of major proportion by any standards and represents the most modern engineering practice in hydraulic design to be found today. Combined with the modern designs of material and equipment are the arts and crafts of the eastern artisan in the huge masonry dams and spillways. Together they make the project as a whole a work of outstanding significance.

But as far as the individuals of our company are concerned the greatest satisfaction we have derived is not in the work itself—although that is not insignificant—but in the friendships we have made and the thoroughly nice people we have added to our circle of friends. We look forward to continuing these associations. We feel your problems will always be ours and if we can in any way help solve them we would be delighted.

C. RITCHIE, *P. Eng.*,
General Manager,
Montreal Engineering Co., Ltd.,
Montreal, Canada

* * *

It has been both a pleasure and a privilege to be associated with the Kundah hydro electric development—a pleasure in that the project has been well conceived and has been pushed vigorously to a successful completion, and a privilege in that the work has afforded such an excellent lesson in international cooperation. In the brief span of four years Kundah has been transformed from an idea on paper into the two hydro electric stations of impressive dimensions. Difficult problems of access have been overcome with the building of 100 miles or more of roads over steep terrain; new towns have been constructed with excellent accommodation for thousands of construction workers and ultimately for hundreds of permanent personnel; community welfare has been maintained at a high standard; great quantity of construction materials have been concentrated in hitherto inaccessible locations and the efforts of numerous contractors and sub-contractors have been coordinated to produce a steady march of progress. To have accomplished all this and at the same time to have overcome the many exigencies that arise in the driving of tunnels and the building of dams is indeed an accomplishment of which the Madras State Electricity Board can be proud.

J. K. SEXTON, *P. Eng.*
Chief Civil Engineer,
Montreal Engineering Co., Ltd.,
Montreal, Canada

* * *

The magnitude of the Kundah Project can best be expressed in terms of the present system. Kundah will add 55% more capacity to the Madras Grid. This new power will accelerate the State's industrial development as well as provide extra power for irrigation

pumping. The Chief Engineer and his staff are to be congratulated for their conception, planning and execution of this large scheme.

I have had the great pleasure of being part of the Canadian engineering team which participated in the Project's execution. One of the privileges associated with this work was a visit to Madras early in the construction stage. This gave me the opportunity to see the work in progress and meet the very competent engineers on the job. The friendliness, cooperation and particularly the ability of the Indian engineers has made our work most enjoyable.

On the occasion of the inauguration of this great project, may I extend my congratulations and also my best wishes to all my good friends in the Electricity Board.

N. RIVINGTON *P. Eng.*
Assistant Chief Electrical Engineer,
Montreal Engineering Co., Ltd.,
Montreal, Canada.

* * *

As one of the Canadian engineers privileged to work on the Kundah project, I am happy to extend my congratulations to the Department of Electricity on the successful commissioning of the plant.

Work on this vast undertaking has been stimulating and has left many pleasant recollections. There were the early meetings with the Engineer, held in Montreal in 1956 for the purpose of expediting the specification and purchase of equipment to meet the special requirements of the project; then the visits to Madras to observe local Indian operating procedures and construction methods to enable us to adapt our Canadian designs to suit site conditions; and, laterly, the recent visits of Madras engineers to Canada to familiarise themselves with Canadian equipment and its operation.

On all of these and other like occasions a spirit of friendly cooperation and pleasantness prevailed which persisted throughout the execution of the project and contributed in no small measure to its successful and happy conclusion.

Again may I proffer my sincere good wishes to Mr. Appadurai and his staff. I congratulate them for their great achievement at Kundah and hope we may renew our pleasant relations on many future undertakings.

W. J. SMITH, *P. Eng,*
Assistant Chief Civil Engineer,
Montreal Engnieering Co., Ltd.
Montreal, Canada.

* * *

It has been a source of great pleasure to me as a Canadian and as an engineer to have had the unique experience of being one of the large group of Indians and Canadians who have worked cooperatively and harmoniously on bringing into being this great Kundah scheme. It is an impressive monument to the skill and vigour of the many Madras State Electy Board Engineers, who under the leadership of their esteemed Chief Engineer, worked through many outstanding and difficult engineering problems so that the benefits of electric power could be spread over the State at the earliest possible date. Kundah's importance to the economy of Madras and to its general welfare will be tremendous and cannot be overemphasized.

The scheme is marked by several major steps in hydro electric construction, but from the utilisation point of view, the outstanding feature has been the addition of a 230,000 volt transmission and substation system to the existing 110,000 volt and 66,000 volt grid of the State. The Madras State Electy. Board will be among the first in India to operate their system at this high level and can be justly proud of their achievement. The effect of the 300 miles of 230 kV. line and its future additions will be to place Madras in a highly advantageous position to provide for industrial and agricultural expansion for many years to come.

May I take this opportunity to extend my best wishes to all of my Indian colleagues and friends and to thank them for a most pleasant and instructive two years in their beautiful country.

H. W. D. ARMSTRONG, *P. Eng.,*
Electrical Engineer,
Montreal Engineering Co., Ltd.,
Montreal, Canada

Introduction

This 35-crores project is indeed the proudest achievement of Madras since independence. When completed, it will add 180,000 kW to the Madras grid, thus adding 55 per cent more of power to the State. Today Madras leads the country in rural electrification and ranks third in generation and utilisation of power.

Kundah is notable for two main reasons. It symbolises the cooperation between two Commonwealth countries, India and Canada, in the execution of a major project. In terms of money Canada has contributed 25 million dollars. But this is only a statistical figure behind which lies the technical cooperation of Canadians which is of inesteemable value. We were till 1947 accustomed to experience development through the method of colonialism and imperialism. Here is an excellent example which typifies a new relation of cooperation between the less developed and the more developed countries.

The other characteristic feature of the Kundah Project has been the excellence of organisational and technical leadership of the Indian engineers in Madras under the leadership of Mr. V. P. Appadurai. Within the course of four years the first power-house has been inaugurated in a project which can be classed as major in any part of the world. Be it noted that this has been accomplished by using a large number of manual labour in the construction of dams and other civil works and by undertaking 15000 ft of tunnelling. This record has impressed foreigners more than anything else.

Quite a number of Canadian engineers had the occasion to visit this project and work shoulder to shoulder with their Indian colleagues. Practically in one voice they have declared that this participation has been of great educative impact on their minds. It was not merely a question of delivering the plants and equipments for the project. They could realise while they were here, the peculiar problems, social as well as economic, that our country faces and in what ways these are so different from those of the West. They also realise that Indian engineers are no less competent than their counterparts in other lands in the field of their experience and that they are able to mobilise traditional methods and practices with such unique organising ability that these can compete fairly with modern mechanized methods. The relevance of such practices in our social context would not have been comprehended by these Westerners had they not seen it with their own eyes. These realisations derived from personal experience have created a new relationship between the Canadians and the Indians and we hope and believe that this will certainly augur well in promoting further occasions of fruitful cooperation between the two countries.

It is interesting to note that Madras has given special emphasis on rural electrification for sometime past. When more power will be available, this policy will help the dispersal of industries, big and small, throughout the State. Industrial civilisation has created big cities with its slums, ugliness and concentration of unemployment. If Madras is able to practice its policy consistently and courageously, it may in course of time develop a pattern of decentralised industries and,

as a consequence, evolve a new mode of community life—an ideal which is so close to our hearts.

The following pages give a brief review of the power development and its prospects in Madras State as well as of the technical features of the Kundah Project contributed by some of those who have been responsible for their planning and execution. In presenting these contributions in this special issue we pay our compliments to all those Canadians and Indians who have given practical shape to the Kundah project and are still doing so.

———

[*Continued from page 9*

Building New India Through International Cooperation

I like coming here among your beautiful mountains because I am myself the child of the Mountains, the mountains of the north, and so I feel at home among mountains and mountain people. And coming here I am glad to meet you the Todas, Kotas, Kurumba people and Irulas whom I met last year. Because we want all of you people to progress, all of you to take part in the great work that we are doing for India and the people of India and you must all remember that whatever our creed, whatever part the country we may live in, we are all one great people, the people of India and we have to work together in friendship and affection for the betterment of all and betterment of our country.

This Kundah Project is a symbol of national as well as international cooperation. Therefore, this represents something that is very good. *It is through the nation working together and cooperating with other nations that we shall progress and the world will progress.* Therefore, again I congratulate all of you who have been associated with this work in whatever degree, whether they have come from Canada or India, whether they are the humble people of the villages here who worked, and I hope that the rest of this project will be as speedily and as well completed as this first phase.

———

Building New India Through International Cooperation

JAWAHARLAL NEHRU

[*Being the Prime Minister's speech on the occasion of the inauguration ceremony of the Power Station No. I of Kundah Hydro Electric Project on March 25, 1960.*]

I am sorry I cannot speak to you in the beautiful Tamil language. I can speak to you in Hindi or English. I do not think many of you will understand my Hindi, but I speak in English; my friend here is going to translate it into Tamil.

Last year I paid a visit to this Kundah project and the engineers here took me round and showed me how this was developing. Now I am happy to be here and to be present at the completion of one major stage of this project and I want to congratulate all those concerned with it—the engineers, Canadian and Indian, other mechanics and workers who have helped in speedily bringing to completion this first phase. It was fitting therefore that the inauguration ceremony should formally be done by one of your own people, one of your worker, rather than by me. He deserves congratulation, as you do, not I for this work. And I should like to express my gratitude and the gratitude of my Government to the Canadian Government for the help they have rendered in this very important scheme in South India. Their help of course is very welcome and we are grateful but it will be even better and makes me happier just to see this project built up with joint cooperation between the Canadian Government and their engineers and our engineers. Because cooperation in these major works like in all others, tor the matter of that in small works, is always good for those who take part in it.

What is this big project over the Kundah river that has been built. You people who are here, or many of you, have helped in building it. What have you built? Not just something in cement and brick and mortar or whatever it is, iron and steel, but you have built something which will endure for a long long time and which will help you or help this area and round about to become more prosperous. Therefore, all of you who have helped in building this have helped to some extent in building the future India that is gradually taking shape all over this country, the New India. So, *you have built not only the Kundah Project which will produce electric power but built partly New India.*

I do not know how our engineers here, explain all this to the worker, because it is important that each worker, whatever job he may do, should understand what he is doing, should understand that this is not only his little work but it is something big that is coming up; that he is taking part in constructing the big scheme which will bring happiness to large numbers of people; that he is taking part in the building up of New India. He must be made to understand that. Only then does his work and the engineers' work become fruitful and full of meaning.

[*Continued on page 8*

Greetings to the

KUNDAH HYDEL PROJECT

CANADIAN aid, under the Colombo Plan, for the huge Kundah Hydro-electric project will be in the form of electrical machinery worth about Rs. 12.5 crores.

Already the **Canadian Westinghouse International Corporation, Toronto** have supplied generators, switchgears, breakers, and ancillary equipment for the No. 1 power house. **Dominion Engineering Company Limited, Montreal,** have supplied turbines and hydro-electric equipment for No. 1 and No. 2 power houses.

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Kundah Power Station Inaugurated

The Power Station No. I of the Kundah Hydro-electric Project in Madras was inaugurated on March 25, 1960 in the presence of a distinguished gathering among whom were Mr. Jawaharlall Nehru, Prime Minister of India, Mr. Bishnuram Mehdi, Governor of Madras, His Excellency Mr. C. A. Ronning, High Commissioner for Canada in India, and the Ministers of the Government of Madras.

Mr. W. R. S. Sathianathan, I. C. S., Chairman, Madras State Electricity Board welcomed the guests and explained some of the interesting engineering features of the project. He then expressed a deep sense of gratitude for the great help rendered by the Canadian government in making this project a success. He paid a glowing tribute to the consulting and other engineers of the Canadian Government and also the technical staff for sparing no efforts in their work and for fully associating themselves with the staff of the Electricity Board. He complimented Mr. V. P. Appadurai, Chief Engineer for Electricity, Madras, for his dynamic energy and enterprise.

Mr. Appadurai addressing the gathering read the message of the Prime Minister of Canada sent specially for the occasion. (The text of the message is given elsewhere in this issue.)

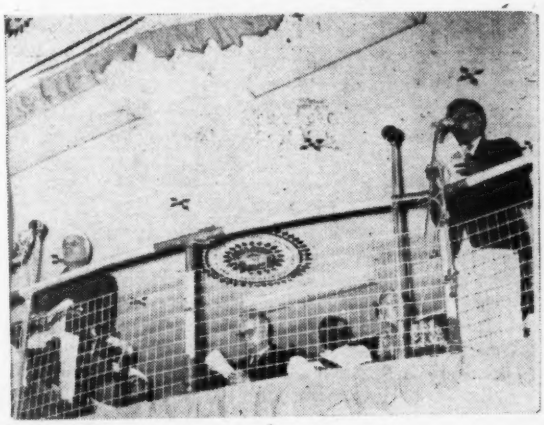
He then explained how the project took rapid shape since Mr. C. D. Deshmukh started the same on 29th. June '56 and was completed in a little over three years and nine months. The Kundah hydro-electric project, he pointed out, is the sixth biggest hydro project to be inaugurated in India in recent years. In its ultimate state of development it will contain four power stations with a total installed capacity of about 420,000 kW. He said that the second unit will begin functioning within a fortnight of the inauguration of the first one. And the second power house is expected to be built by the middle of 1960. By the 31st. of March '61 all the six units totalling 180,000 kW will be under commission.

Mr. Appadurai then explained the future stages of development. He said: The stage that is now under construction contemplates completion of two power projects between 31st March 1961. Now, this still leaves us with 1700 ft. head and 1000 cusecs of water which will develop about 240,000 kW of power and we have submitted plans, proposals etc. to the Planning Commission and the Control Water & Power Commission. The C. W. & P. C. have agreed to the technical aspects of the scheme and it is now before the Planning Commission. The estimated cost of the project is about 23 crores of rupees and the foreign exchange component is just about 15 million dollars. If we are very lucky to get the extension of the Colombo Plan assistance to this stage, we will be adding for 15 million dollars about 240,000 kW of power. So we hope the Canadian Government will try to assist us in completing this project that is utilising all the waters of the Kundah from the moment they start from Avalanche down right to the Bhavani water.

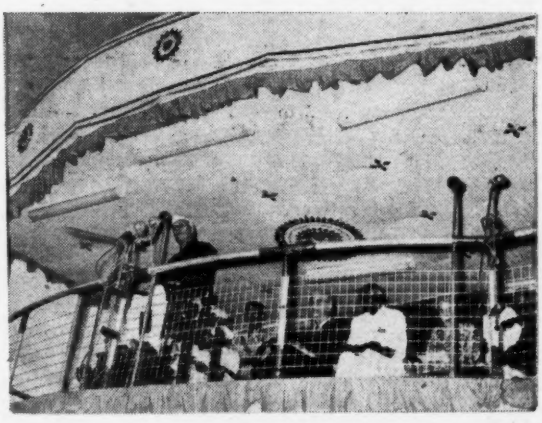
After Mr. Appadurai's speech Mr. Sardar Khan, the oldest worker of the project switched on and immediately bells began ringing and the noise of the machine running was heard.

Finally, the gathering was addressed by His Excellency Mr. C. A. Ronning and Prime Minister Nehru. (Mr. Nehru's speech is given elsewhere in this issue.)

Mr. V. P. Appadurai reading the Message from the Canadian Prime Minister.



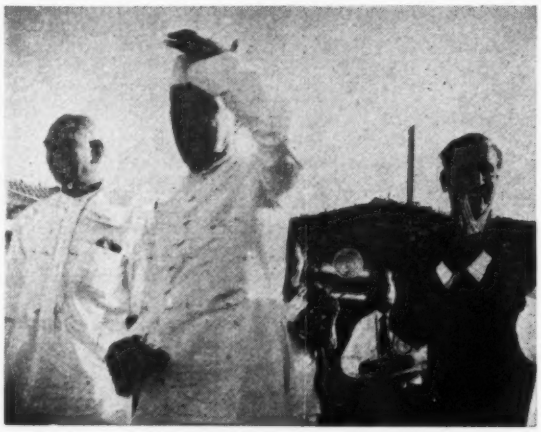
Prime Minister Nehru addressing the gathering



In the course of his address Mr. Ronning said that "It is the greatest project in which Canada has co-operated with India in India although it is not the first" He then remarked that he hoped that it was not the last inauguration which the Governor will attend together with him. He further said that during his last visit two years ago it was an inspiring sight to see that so many people could work together on a project like this. "I was amazed at the skill of the men who cut the stone and the skill of the people who carried those huge stones up the steep hills and the efforts of the thousands of men, women and even children who carried on their heads stones that were large, that were medium size, that were small and brought them to the skilled workemen who put them down into the mortar and concrete which has resulted eventually in the dams that are part of this great project."

Mr. Ronning referred to Mr. Nik Cavell, "the first Canadian who was inspired to recommend that Canada should participate in this project". Mr. Cavell is at present High Commissioner for Canada in Ceylon. Another person to whom Mr. Ronning paid tribute was Mr. Appadurai. He said "the man about whom I am thinking now is a person who has, perhaps more than any other single person, not only had the vision but has been able to carry out that vision in record time. One would have thought that the project should have taken at least 10 years and the first power house is being inaugurated today in a little over three years time. *The man who has done more than any other man to achieve this is your Chief Engineer, Mr. Appadurai.*

Sardar Khan, oldest worker, Switches on the first Generator.



Sri K. Kamaraj, Chief Minister, Madras, with Prime Minister Nehru and Mr. Appadurai

We are proud that Canadian engineers particularly Mr. Armstrong, and Mr. Grandy who have been with this work from the beginning have been fortunate enough to have men like Mr. Appadurai and his staff of engineers to work with and we take a great deal of satisfaction in being able to state here today that cooperation has been excellent and has not been marred at any point. We hope that future undertakings will also be characterised as this one has ben characterised by such complete—co-operation."

Speech delivered by Sri V. P. Appadurai, B. A., M. I. E. (Ind.), Chief Engineer for Electricity, Madras State Electricity Board, on the occasion of the inauguration of the Kundah hydro electric power station No. 1 on 25th March, 1960.

Revered Prime Minister, His Excellency the Governor, High Commissioner for Canada, our Chief Minister, Ministers of the Madras Govt. and distinguished ladies and gentlemen.

Before I begin to say anything I have to tell you that we have received a number of messages from all over the world and owing to shortage of time I will read to you just the message received from the Prime Minister of Chanada who could not be present on this occasion.

We are gathered here to see the running of the first machine of the Kundah hydro electric project which was started by Mr. C. D. Deshmukh on the 29th of of June 1956 and within a little over three years and nine months we are very pround that we are able to get our Prime Minister to see the commissioning of the first unit. The Kundah hydro electric project is very important in respect of the following aspects. First, this is the sixth hydro electric project, the biggest of a series of power stations that will be utilising the waters of the Kundah river. In the ultimate stage of development there will be four power stations with a total installed capacity of about 420,000 kW. The first stage now under construction envisages the

construction of two power houses with a total installed capacity of 180,000 kW. Now the first unit has started to run and will be running in a few minutes and the second unit within a fortnight and we will be pleased to see the second power house commencing operation by the middle of this year and all the six units of total of 180,000 kW will be added on the Grid before 31st March next year.

We are very grateful to the Government of Canada for the magnificient aid of 25 million dollars without which it would not have been possible for us to go ahead with the implementation of the scheme. This project is a symbol of international co-operation, understanding, thinking and friendship and the fruits of the labours of these two Commonwealth countries, India and Canada will lead to the addition of 180,000 kW of power to the Madras Grid.

Now, the per capita consumption which is the yardstick of the measure of the prosperity of the country is 44 units for Madras at present while the all-India average is about 30 units. With the addition of the Kundah hydro electric scheme, this will jump up to 62 units i.e., the prospertity of Madras State has increased by 40% by the addition of the Kundah hydro electric scheme under the magnificient contribution from the Colombo Plan assistance by the Canadian Government.

The stage that is now under construction contemplates completion of two power projects before 31st March 1961. Now this still leaves us with 1700 ft. head and 1000 cusecs of water which will develop about 240,000 kW of power and we have submitted plans, proposals etc. to the Planning Commission and the Central Water & Power Commission. The C.W.P.C. have agreed to the technical aspects of the scheme and it is now before the Planning Commission. The estimated cost of the project is about 23 crores of rupees and the foreign exchange components is just about 15 million dollars. If we are very lucky to get the extension of the Colombo Plan assistance to this stage we will be adding for 15 million dollars, about 240,000 kW of power. So, we hope the Canadian Government will try to assist us in completing this project that is utilising all the waters of the Kundah from the moment they start from Avalanche down right to the Bhavani water.

We are very grateful to you, Sir, for having found time to inaugurate the function and in deference to the wishes of the Prime Minister, we are having the oldest worker, one Mr. Sardar Khan to switch on. When he switches on we will hear the bells ringing and we will hear the noise of the machine running.

Mr. Sardar Khan will now press the switch.

Speech delivered by Mr. C. A. Ronning, High Commissioner for Canada in India, on the occasion of the inauguration of the Kundah hydro electric power station No. 1 on 25th March 1960.

Mr. Chairman, Prime Minister, Mr. Governor, distinguished Ministers, ladies and gentlemen, workers who have contributed your efforts towards the completion of this great project.

It is quite an honour for me today to represent the Government and people of Canada at this occasion. It is a pleasure and honour because, may be, this is the sixth project in India of its type but it is the greatest project in which Canada has co-operated with India in India although it is not the first. There is on the platform today your Governor who, a few years ago was the Chief Minister of Assam. He and I both attended the inauguration of the first Canadian hydro electric porject in India which we co-operated with you in constructing. I hope this is not the last inauguration that the Governor will attend together with me. It is our plan, in due course, to attend the inauguration you will have for next power house and we are hoping upon that occasion to bring the Minister from Canada to attend the ceremony.

Two years ago my wife, two children and I visited Kundah. We were greatly impressed by the activity in these hills. The roads had been built for transportation, buildings to house the workers had already been constructed and ten were the thousand people building three dams, digging three tunnels and constructing two power houses.

It was an *inspring* sight to see that so many people could work together on a project like this. I was amazed at the skill of the men who cut the stone and the skill of the people who carried those huge stones up the steep hills and the efforts of the thousands of men, women and even children who carried on their heads stones that were large, that were medium size, that were small and brought them to the skilled workmen who put them down into the mortar and concrete which has resulted eventually in the dams that are part of this great project.

The project is now nearing completion and it is an honour for Canada to be represented here particularly because as, your Prime Minister has said, this represents the joint effort and I am happy to be able to say that from the Canadians who have been working here I have heard only reports of great respect for their co-workers and there has been most hearty co-operation from the beginning upto the present time and I am sure it will continue until the completion of this effort.

I bring you today greetings from a man, the first Canadian who was inspired to recommend that Canada should participate in this project. I happened to be on the Colombo Plan Committee of Canada at that time and remember very well about the adoption of his recommendation. The man of whom I am speaking is at present our High Commissioner in Ceylon. His name is Nik Cavell. He would like to have been here today, but it is impossible for him to come but he has asked me to give his greetings and I would like to pay a tribute before I sit down to the man whose vision inspired, Nik Cavell, to ask the Canadian Colombo Plan Committee to co-operate with you in constructing this project.

The man about whom I am thinking now is a person who has perhaps more than any other single person, not only had the vision but has been able to carry out that vision in record time. One would have thought that the project should have taken at least 10 years and the first power house is being inaugurated today in a little over three years time. The man who has done more than any other man to achieve this is your Chief Engineer, Mr. Appadurai. We are proud that Canadian engineers particularly Mr. Armstrong, and Mr. Grandy who have been with this work from the beginning have been fortunate enough to have men like Mr. Appadurai and his staff of engineers to work with and we take a great deal of satisfaction in being able state here today that co-operation has been excellent and has not been marred at any point. We hope that future undertakings will also be characterised as this one has been characterised by such complete co-operation.

I wish you the best of success in carrying on the project whether or not we continue to participate after the first two phases have been completed. No one is able to predict today but I am sure that you will continue until all four phases of this great project has been completed for the benefit of the people of the State of Madras—for the villages, lights and pumps to lift water and for industrialisation of the State of Madras.

Thank you.

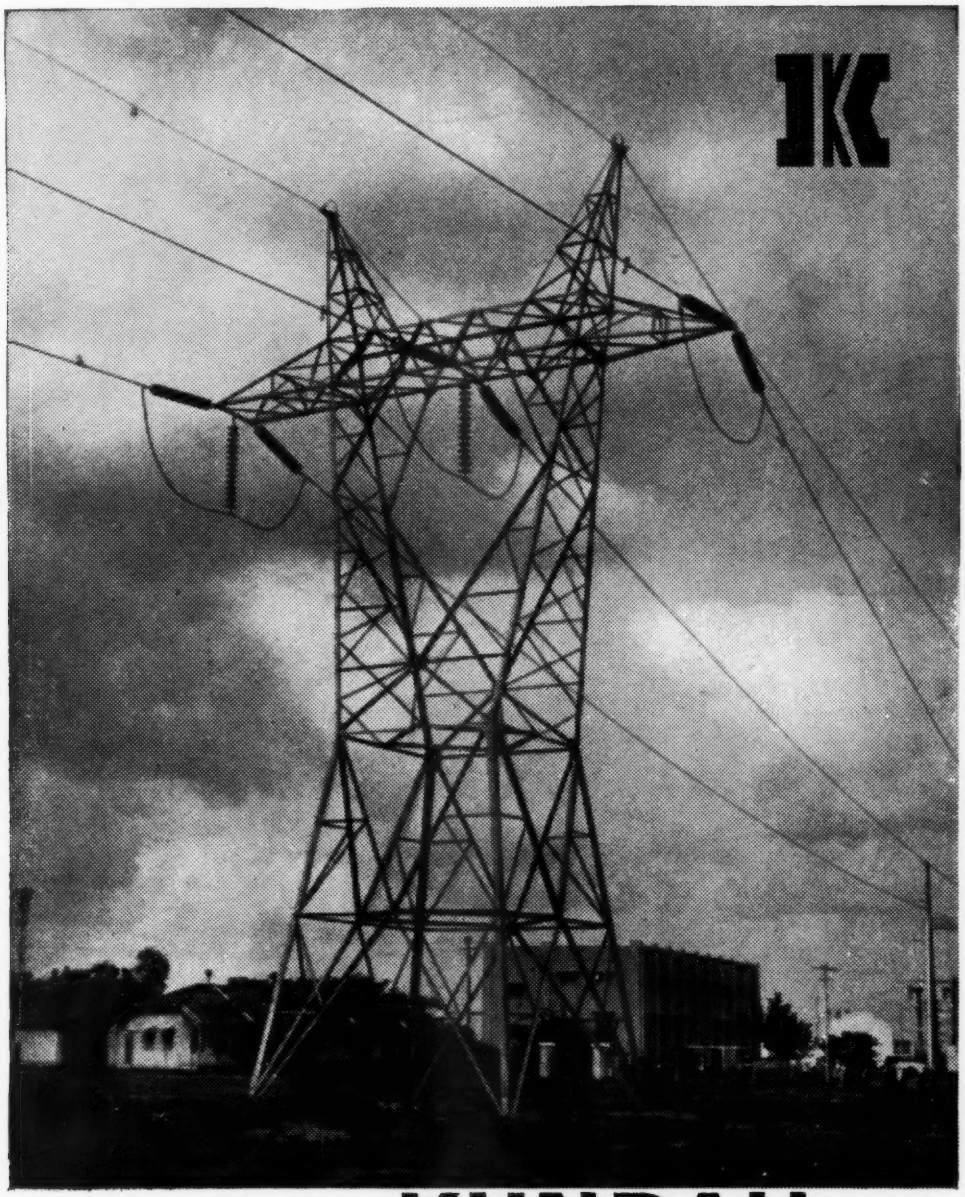
THUS THE PROJECT PROGRESSED

Events:

January '52	Scheme report sent to Government
February '54	Revised Report sent to Government
September '55	Scheme Sanctioned
June '56	Inauguration of the Scheme by Sri C. D. Deshmukh
March '60	Inauguration of the first Power Station in the presence of Sri Jawaharlal Nehru

Progress of Works

Works	*Commencement*	*Completion*
Emerald	June 1956	In progress
Avalanche Dam	-do-	-do-
Tunnel I	July 1957	March '60
Penstock I	June 1956	January '60
Power House	-do-	March '60
Forebay Dam,	-do-	In progress
Tunnel II	July 1957	In progress
Penstock II	September 1956	-do-
Power House II	October 1956	-do-



KUNDAH HYDRO ELECTRIC PROJECT

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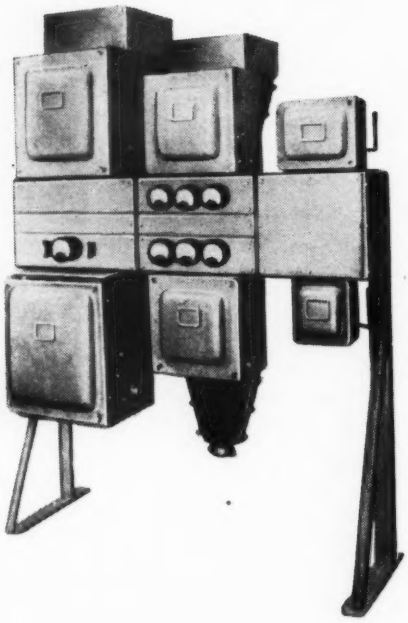
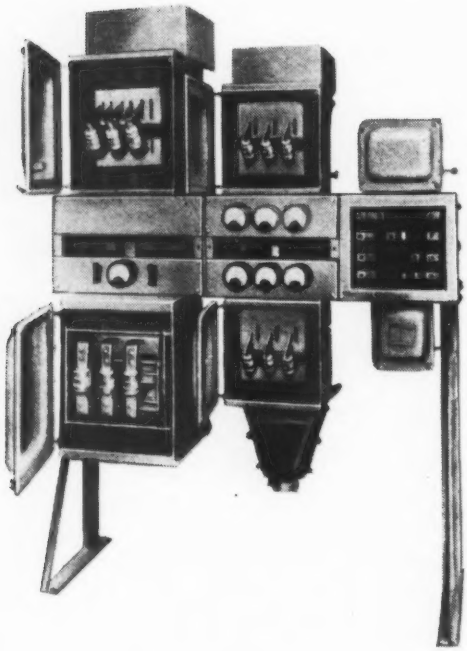
Construction





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Power Development in Madras State

Today Madras State ranks third in India in generation and utilisation of power, Bombay and Bengal leading. In respect of utilisation of power for irrigation purposes we stand first by way of number of consumers, consumption and connected load. In the matter of hydro electric output, Madras is second only to Bombay. It is hoped that with the commissioning of the Kundah hydro electric scheme Madras will lead in hydro electric output. While the bulk of the power in Bombay and West Bengal is consumed in big industries and urban loads, Madras has built up an electricity grid extending into almost all the districts and rural areas. In fact, Madras leads the rest of India in rural electrification with over 9,100 towns, villages and hamlets taking electricity supply by March 1960.

POWER GRID

The Madras power grid covers all the districts of the State and comprises:

Five hydro electric power stations

Pykara	..	70,200 kW
Moyar	..	36,000 kW
Mettur	..	40,000 kW
Papanasam	..	28,000 kW
Periyar	..	105,000 kW

Two thermal power stations

Madras	..	98,500 kW
Madurai	..	14,000 kW
		391,700 kW

13,900 miles of high tension transmission lines of voltages varying from 11,000 to 110,000;19,000 miles of low tension distribution lines; and 67 EHT and 70 HT substations and 8,800 distribution stations.

The grid is serving electricity to 6.7 lakhs of consumers, about 80% of them served directly by the Board and the rest served through 5 municipal licensees and 8 private licensees.

The aggregate peaks of the systems during the year was 410,000 kW while the coincident peak of the Grid was 336,000 kW. Power generated during the year will be 1900 million units of which about 76 per cent will be from water power and the balance from coal. The entire power output in the State is produced by the Electricity Board.

The total capital investment to the end of March 1959 will be Rs. 119 crores and the annual gross revenue during the year is over Rs. 15 crores.

By V. P. APPADURAI

HISTORY

Power generation in the Madras State until about 1908 was confined mainly to a few tiny plants in tea estates run on water power, and to the small hydro installation at Kateri in the Nilgiris.

The first public electric supply in the State was commenced in Madras City in 1909 by the Madras Electric Supply Corporation under licence.

Real progress dates from 1925 when the Government of Madras initiated the policy of active development of the power resources by the State.

In furtherance of this policy the first hydro electric scheme viz., the Pykara scheme was taken up in 1929 and the station came into opration in June 1937 and the Papanasam power house in April 1944. The first thermal station to be erected by the Department was commissioned early in 1951 at Madurai.

The first Five Year Plan period was confined to construction of a new power house at Moyar and extensions to the existing stations at Pykara, Papanasam, Madurai and Madras. The installed generating capacity increased by nearly 65 per cent from 156,000 kW to 256, 700 kW.

The third stage extensions at Madras comprising of a 30,000 kW was completed in April 1958 and the Periyar hydro electric scheme was commissioned in October 1958.

SECOND FIVE YEAR PLAN

Power schemes of the Madras State included in the second Plan as originally approved by the Plan ning Commission were estimated to cost Rs. 60.03 croses. The economy cut and the reconstitution of the State reduced this to Rs. 53.25 crores. It is now expected that the final outlay will be around Rs. 71.31 crores forming 38% of the total outlay for the State.

The schemes on completion will more than double the installed generating capacity, length of lines and the number of towns and villages electrified. Table I gives the targets for the second Plan under generation, trasmission and distribution for the Madras State; for purposes of comparision the All India targets are also given.

Table I

Particulars	*All India target* 55-56	60-61	*Percentage increase*	*Madras target* 55-56	60-61	*Percentage increase*
Generation :						
Installed generating capacity in 1000 kW	3400	6800	100	256	571	123
Units generated in millions	11000	22000	100	1055	2500	136
Transmission :						
H. T. Lines-11kV and above.	35000	70000	100	7343	15500	112
Distribution :						
No. of villages & towns electrified.	7400	18000	145	3543	10000	183

PROGRESS

Generation

The Madras Plant Extensions (III Stage) which envisaged the erection of a 30,000 kW set with two 150,000 lbs/hr. boilers were commissioned in April 1958.

The first unit of Periyar hydro electric scheme was commissioned in October 1958, the second unit in February and the third in May 1959 adding 105,000 kW installed generating capacity to the grid.

The plant no. 1 of Kundah hydro electric scheme was commissioned in March by the Prime Minister and it is programmed to commission the plant no. 2 in July or August this year.

Thus during the first four years 155,000 kW has been added and the balance of 160,000 kW will be added during the final year of plan.

Transmission

Including the transmission lines proposed under the Kundah and Periyar hydro electric schemes, an additional 8,200 miles of E. H. T. and H. T. lines and 12,000 miles of L. T. lines will be erected during the Plan period. Of these, 6,400 miles of E.H.T. and H.T. lines and 10,900 miles of L. T. lines have already been erected during the first four years of the Plan period. A major stride in respect of transmission during the second Plan period is the first 230 kV line in the State from Kundah to Madras recently completed which will convey power generated at Kundah to Madras, a distance of about 300 miles.

Rural Electrification

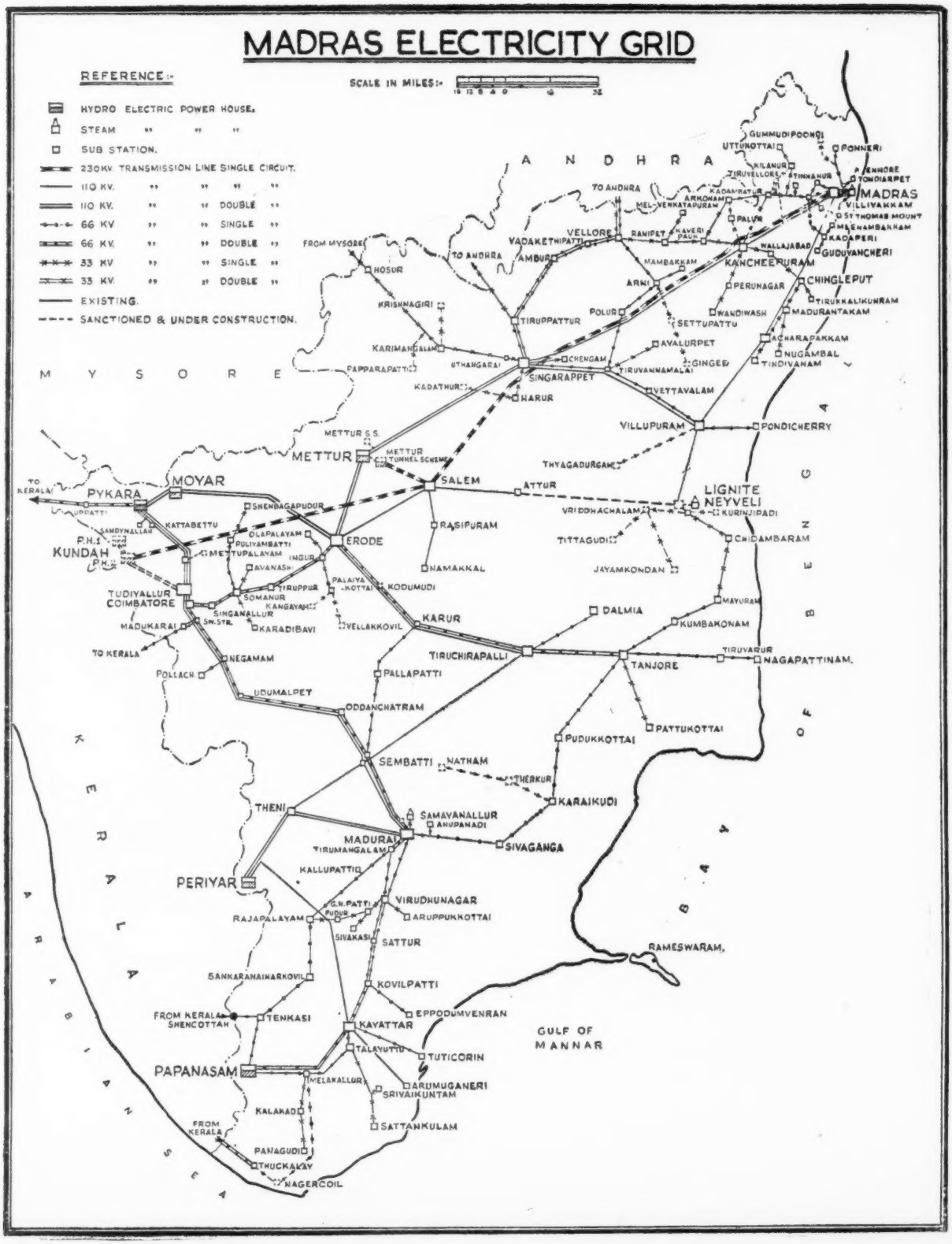
Madras continues to maintain its lead in the matter of rural electrification with over 9100 towns, villages and hamlets electrified by February 1960. During the second Plan period, it was proposed to extend electricity to 5,000 additional villages. This target has been exceeded during the current year and it is expected that about 6200 villages and hamlets will derive the benefits of electricity during the second Plan period. About 32,440 pump sets were working on electricity at the end of the first Plan period. Today nearly 98,000 pump sets are working on electricity.

Table 2 gives the power development of the Madras Grid under the Five Year Plans. It may be seen from the table that there has been a phenomenal development during the second Plan period.

Table 2

Five Year Plans

(1)	*At the beginning of 1st Plan* 31.3.1951 (2)	*At the end of 1st Plan* 31.3.1956 (3)	*At the and of 2nd Plan* 31.3.1961 (4)
Generation :			
Installed generating capacity in M. W.	156	256	571
Aggregate demand in MW.	130	208	560
Units generated in millions.	630	1053	2500
Transmission :			
Length of HT lines in miles.	4355	7343	15500
Length of LT lines in miles.	3580	8128	20000
Distribution :			
No. of consumers in lakhs.	2.5	4.26	8
Substation including distribution transformers	1647	3862	10150
Rural electrification :			
No. of villagese lectrified.	1613	3320	10,000
No. of agricultural pump sets connected.	14373	32440	100,000
Finance :			
Capital outlay in crores.	30.96	54.01	125.34
Gross revenue in crores.	3.37	7.03	18.42


MADRAS ELECTRICITY GRID
REFERENCE :-
HYDRO ELECTRIC POWER HOUSE.
STEAM " " "
SUB STATION.
230 KV. TRANSMISSION LINE SINGLE CIRCUIT.
110 KV. " " " "
110 KV. " " DOUBLE "
66 KV " " SINGLE "
66 KV. " " DOUBLE "
33 KV. " " SINGLE "
33 KV. " " DOUBLE "
EXISTING.
SANCTIONED & UNDER CONSTRUCTION.
SCALE IN MILES :-
A N D H R A
M Y S O R E
K E R A L A
BAY OF BENGAL
ARABIAN SEA
GULF OF MANNAR
GUMMUDIPOONDI
UTTUKOTTAI
PONNERI
KILANUR
TIRUVELLORE
ATHNANUR
AVADI
TONDIARPET
MADRAS
VILLIVAKKAM
ST THOMAS MOUNT
MELAMBAKKAM
KADAPERI
GUDUVANCHERI
WALLAJABAD
KANCHEEPURAM
CHINGLEPUT
TIRUKKALIKUNRAM
MADURANTAKAM
ACHARAPAKKAM
NUGAMBAL
TINDIVANAM
PERUNAGAR
WANDIWASH
SETTUPATTU
AVALURPET
GINGEE
TIRUVANNAMALAI
VETTAVALAM
VILLUPURAM
PONDICHERRY
THYAGADURGAM
LIGNITE
NEYVELI
KURINJIPADI
VRIDDHACHALAM
CHIDAMBARAM
TITTAGUDI
JAYAMKONDAN
MAYURAM
KUMBAKONAM
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TANJORE
PATTUKOTTAI
PUDUKKOTTAI
KARAIKUDI
SIVAGANGA
SAMAVANALLUR
ANUPANADI
NATHAM
VERKUR
SEMBATTI
DALMIA
TIRUCHIRAPALLI
PALLAPATTI
KARUR
VELLAKKOVIL
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SALEM
ATTUR
SINGARAPPET
NARUR
KADATHUR
PAPPARAPATTI
UTHANGARAI
CHENGAM
KARIMANGALAM
KRISHNAGIRI
TIRUPPATTUR
POLUR
HOSUR
FROM MYSORE
TO ANDHRA
AMBUR
VADAKETHIPATTI
VELLORE
RANIPET
KAVERI PAUK
ARKONAM
MEL-VENKATAPURAM
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PALUR
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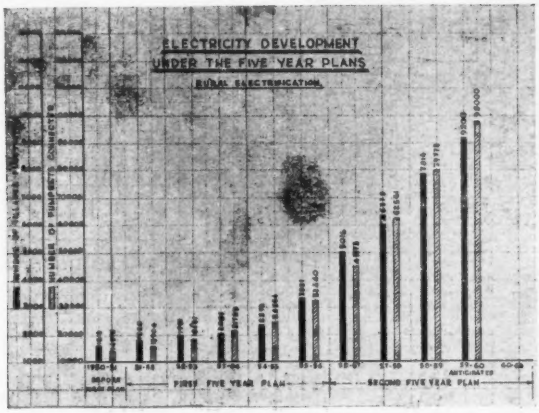
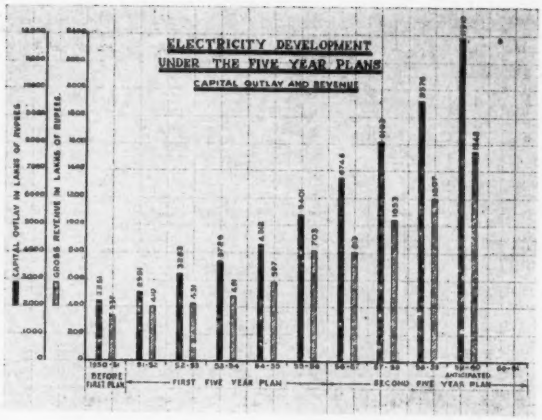
PYKARA
TO KERALA
KUNDAH P.H.1
KUNDAH P.H.2
SANDYNALLAH
KATTABETTU
SHENBAGAPUDUR
OLAPALAYAM
PULIYAMBATTI
METTUPALAYAM
INGUR
AVANASH
TIRUPPUR
SOMANUR
KANGAYAM
SINGANALLUR
SW.STR.
KARADIBAVI
MADUKARAI
TUDIYALLUR
COIMBATORE
TO KERALA
NEGAMAM
POLLACH
UDUMALPET
ODDANCHATRAM
THENI
PERIYAR
MADURAI
TIRUMANGALAM
KALLUPATTI
G.N.PATTI
PUDUR
VIRUDHUNAGAR
ARUPPUKKOTTAI
RAJAPALAYAM
SIVAKASI
SATTUR
SANKARANAINARKOVIL
KOVILPATTI
FROM KERALA
SHENCOTTAH
TENKASI
EPPODUMVENRAN
KAYATTAR
TALAYUTTU
TUTICORIN
PAPANASAM
MELAKALLUR
ARUMUGANERI
SRIVAIKUNTAM
SATTANKULAM
KALAKAD
FROM KERALA
PANAGUDI
THUCKALAY
NAGERCOIL
RAMESWARAM.



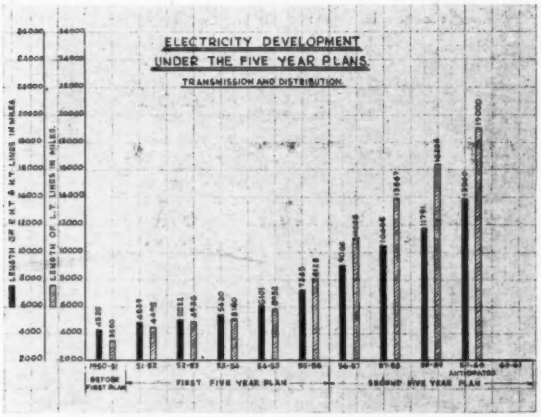


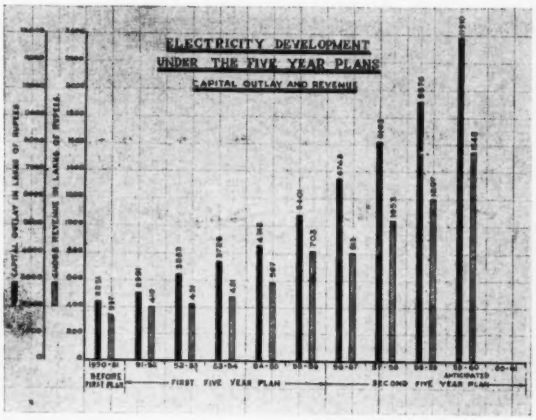
CONCLUSION

The demand for power in the State is widespread and insistent. Several new industries are being planned all over the State and power for them is to be provided from the grid.

To meet the ever increasing demand an ambitious programme has been drawn up for implementation in the third Plan period. The schemes estimated to cost Rs. 133 crores will more than double the present installed capacity. Eight thousand additional villages in the interior will get the benefits apart from 75,000 agricultural pump sets.

With these schemes, we hope to march ahead in the field of social economic development of our State by the spread of electricity, especially to the rural areas and raise the standard of living of the common man and bring brightness and happiness toevery home.





Continued from page 38]

PROGRESS

The maximum outturn achieved per day is about 120 units (1 unit=100 cft). Quite a large number of piece workers are engaged on every dam in order to create competition and good progress. This procedure has proved quite successful. The quality control is maintained under the strict supervision of the departmental staff by strictly adhering to the specification issued by the department for masonry.

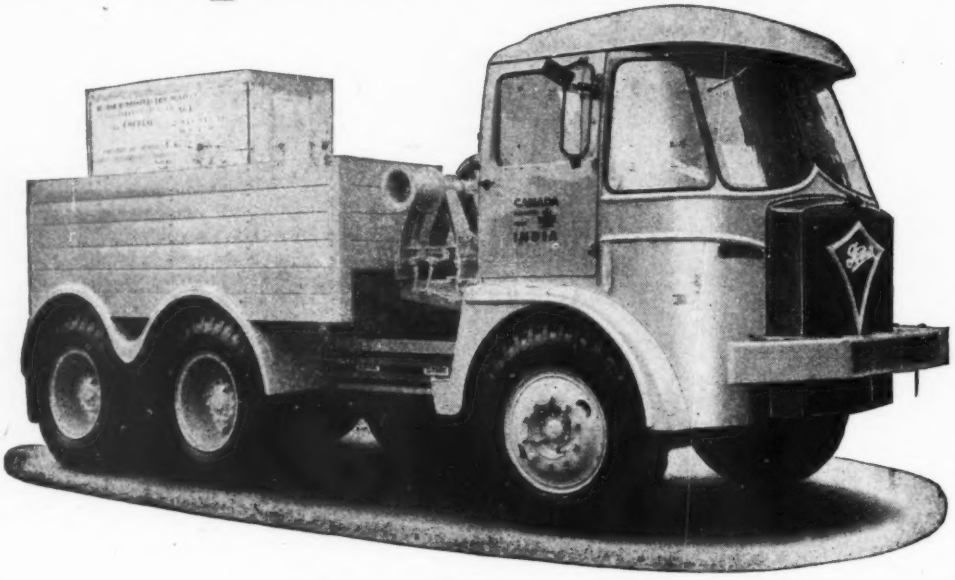
The construction of Kundahpalam forebay dam has been practically completed. The Avalanche and Emerald dams have been raised to about 80 to 100 feet above the deep bed. The Upper Bhavani dam has been taken up at a later stage and is in progress.

High Dams in Kundah Project

The magnitude of the construction in all the four dams can be visulalised by the following figures:—

(*i*)	Approximate quantity of stone masnory in all the four dams.	400,000 units.
(*ii*)	Approximate quantity of river sand.	46,000 ,,
(*iii*)	Approximate quantity of river sand:	200,000
(*iv*)	Approximate quantity of cement:	180,000 tons.
(*v*)	Labour employed. ..	8,000
(*vi*)	Approximate cost of all the dams.	Rs. 800 Lakhs.

More power for India



with Foden's aid!

This Foden FCNHT 6/50 six-wheeled independent heavy-duty tractor unit was supplied for use in the Kundah Hydro-Electric Project.
Powered by Cummins N.H.-6 Diesel engine developing 220 b.h.p. 12 speed double underdrive gearbox and hub reduction gear.
Hydraulic power assistance to steering. S.20 all metal tropical type cab.
24 tons capacity rear bogie.
Darlington 70,000 lbs. pull winch.
Special ballast body to facilitate adjustment of standard ballast weights to give required tractive effort, to suit given train load and/or gradient.

where power is needed

Foden is supreme

FODENS LTD ELWORTH WORKS SANDBACH CHESHIRE ENGLAND

Kundah Hydro Electric Scheme

By V. P. APPADURAI

The Kundah Hydro Electric Project is the sixth hydro electric project undertaken by the Department. It is the most important power project of the second Plan now under execution and is the biggest scheme so far launched to develop the available power resources of the State.

HISTORY

The Kundah Hydro Electric Project in the Nilgiris is one of the projects mentioned by J.W. Meares (the then Chief Engineer for Hydro Electric Survey of India) in his "Preliminary Report on the Water Power Resources of India" published in 1919. In that report the power envisaged was only about 15 MW. utilising a head of 3,000 ft. The scope of the scheme has now been enlarged by the addition of flow from neighbouring basins to generate a firm power of 342 MW with an installed capacity of 420 MW in two phases utilising a head of over 5000 ft. The history of the scheme can be traced from 1921 when a concession for developing power fromKundah falls was given to M/s. Tatas. No attempts were however made by them to develop power and the concession appears to have been subsequently withdrawn.

The Kundah hydro electric scheme was investigated in detail during the 1st Plan period itself. A scheme report was submitted to Government and Central Water and Power Commission during January 1952. The scheme was then revised after scrutiny by the Central Water and Power Commission and the revised scheme was sent to Government during February, 1954. This was scrutinised by the Central Water and Power Commission as well as the Planning Commission. The scheme was finally sanctioned by the Government during September, 1955 at an estimated cost of Rs. 3,544 lakhs including transmission lines. The scheme was inaugurated by Sri C. D. Deshmukh, Union Finance Minister on 29th June 1956.

LOCATION

The plan and profile of the scheme is on the following page. Kundah Basin is located in the Western catchments between latitude 11°10′ and 11°25′ north and longitude 76°30′ and 67°48′ east. The basin is situated to the south-east of the Pykara basin in the Nilgiris. Two streams, the Avalanche and the Emerald, rising amidst the group of high peaks, Devabetta, Karaikada, Koulinbetta and Porthimund, all over 8000 ft. in altitude, combine to form the Kundah river. After the confluence the river takes a south-easterly course and is joined by the Sillahalla near Mandanai at an altitude of 6000 ft. The Kundah has then a fall of about 200′ and runs in cascades for about 2000 ft. to reach the bridge near Kundah Village where it is joined by the Kanarahalla and Koulimulihalla streams. Below the bridge the river runs in cascades till it reaches a level of 2100 ft. above M. S. L. where it is joined by the Pegumbahalla stream. Beyond that confluence it runs in rapids for about a mile and a half and later, in an easy gradient down to its junction with the Bhavani at an altitude of 1340 ft.

PROPOSALS

The development of the Kundah basin has been taken up in phases with 4 power stations and an auxiliary power station. The initial phase envisaging the construction of 2 power houses as given below is under execution during the second Plan period:—

(i) A combined storage by building 2 dams, across Avalanche and Emerald streams of capacity 5500 M-Cft. with an inter-connection tunnel.

(ii) A reservoir at Upper Bhavani of storage 3572 M. Cft capacity and a tunnel 9740 ft. long to connect this to Avalanche reservoir.

(iii) Pressure tunnel about 15000 ft. long from Avalanche reservoir to surge tank 1 from where penstocks lead to Power House.

(iv) Power House 1 on the right bank of the Kundah river near Kundah Palem village with a gross head of 1177 ft. and an installed capacity of 40 M.W.

(v) Forebay Dam for power house II across the Kundah river near Kundah village to collect the tail race water of power house 1 and the run off from its free catchment of 44 sq. miles.

(vi) Pressure tunnel about 12000 ft. long from the forebay to a surge tank and penstocks therefrom to power house II located on the left bank of Pegumbahalla stream.

(vii) Power House II utilising a gross head of 2470 ft. with an installed capacity of 140 M.W.

CANADIAN AID

During the visit of the Canadian Administrator of the Colombo Plan, Mr. H. G. Nik Cavell, in February 1955, the Government of India among other schemes suggested the possibility of providing the power house requirements of the Kundah hydro electric scheme under the Canadian Aid, In a conference held with the Madras Government representatives, the technical aspects of the scheme were explained.

As a result of the Canadian Administrator's keen interest, the Canadian Government deputed during November, 1955, their Engineering Consultants M/s. Montreal Engineering Co., Canada represented by M/s. D. Stairs and J. K. Sexton to the project site. They had discussions with the engineers of the Department. As a result of their recommendations, that the scheme is technically sound, a deputation consisting of Sri C. V. Narasimhan, I. C. S, the then Joint Secretary, Ministry of Finance, Department of Economic Affairs, and Sri V. P. Appadurai, Chief Engineer for Electricity, Madras went to Canada in May 1956 for further discussions and finalising the agreement. The discussions were successfully concluded and an agreement was signed at New Delhi on 29th December 1956. By this agreement, the Canadian Government is to give aid to the tune of 20 million dollars (about 10 crores) by way of plant and machinery for the project. As this aid was found to be not adequate to meet the requirements of transmission lines, the Canadian Government were approached again for additional aid. They generously agreed to give an additional aid of 5 million dollars for transmission lines to link up the power houses with the existing grid.

PRINCIPAL STRUCTURES

Emerald and Avalanche Dams

The Emerald and Avalanche Dams are being built across the two arms of the Kundah river, Emerald and Avalanche streams. They are situated at a distance of 18 miles from Ooty. Both the Dams are of stone masonry gravity type providing a total useful storage of 5500 million cft. The reservoirs have a catchment area of about 22.6 sq. miles. The Emerald Dam is of non-overflow type and the Avalanche Dam is of spill way type with a spill way of 95 ft. wide.

The details of the dams are as follows :—

	Avalanche.	*Emerald.*
Length of the dam in ft.	1200	1060
Maximum height in ft.	186	212
Top width in ft.	21	21
Capacity	5500 M. Cft.	
Total quantity of masonry	1,10,300 Units	1,16,750 Units.

The two reservoirs thus formed are interconnected by a tunnel 2440 ft. long of horse shoe shape (9′-7½″ × 9′-7½″) with a discharge capacity of 750 cusecs.

Upper Bhavani Dam and Tunnel

The dam is built across the Bhavani river at its upper reaches. The dam will be 1400 ft. long at its top 266 ft. high and 21 ft. wide at the top. The storage of the reservoir will be 3572 M. cft. and the reservoir will be connected to the Avalanche reservoir by a tunnel 9740 ft. long of horse-shoe shape.

Tunnel. I.

The water from the Avalanche and Emerald reservoirs is taken through a tunnel with a horse-shoe section 9′-7½″ × 9′-7½″. The tunnel is 14790 ft. long with a discharge capacity of 750 cusecs.

The tunnel commences with a 10′-0″ diameter steel pipe for a distance of 505′ and then it is excavated in rock.

Surge shaft. I.

The tunnel I ends in a surge shaft 275 ft. in depth cut 35′ in earth and balance in rock. The surge shaft is of 28 ft. diameter in the earth portion and 25 ft. diameter in rock. The walls of the surge shaft have been lined with reinforced concrete lining.

Penstock. I.

From the surge shaft, the water travels through a tunnel of 900 ft. At the end of the tunnel there is a trifurcating manifold 108″/63″ × 68″ × 63″ with three 63″ butter-fly valves.

From this manifold, two high tensile steel penstock pipes each 3241 ft. long with diameter of 63″/57″/51″ and thickness 5/16″ to 9/16″ carry the water to the turbines. The penstocks are made of a special grade of high tensile steel. U. S. T. I. steel, a low carbon quenched and tempered steel, with 95000 pounds yield point and 105,000 pounds breaking stress. This steel is readily weldable without preheating or stress relieving. It has 3 times the yield strength of ordinary steel and 4 times the atmospheric corrosive resistance of carbon steel. This is the first time, that such a type of steel is being used in India for penstock pipes. The total weight of the pipe lines is about 940 tons. These pipes were supplied by M/s. Davie Ship building Co. Ltd., Canada. Space provision has been made to add a third penstock at a future date.

Power Plant and Transformer yard I

The power house building is of structural steel frame and stone masonry walls. The building is 202′-6″ long, 80ft. wide and about 50 feet high from the generator floor level. This has been built to accommodate all the three generating units of the ultimate stage of development.

The power plant consists of two multiple jet (5) jets) impulse type vertical turbines supplied by M/s. Dominion Engineering Co. of Canada. They are rated to develop 28,750 H. P. at a net head of 1040 ft. and at 428 R. P. M. Each turbine is directly coupled to a generator rated at 24,000 kVA at 0.9 pf. 11 kV., 50 cycles. The generators are supplied by M/s. Canadian Westinghouse International Ltd.

The transformer yard adjacent to the power station contains seven 8000 k. V. A., 11 kV/110 kV single phase transformers for stepping up the voltage to 110 kV. The transformers are of Canadian General Electric make. Provision has been made for 3 more single phase transformers to be installed at a later date for the third generator. A double circuit 110 k.V. line takes off Power House No. 2 from here.

Kundah Palam Forebay Dam.

The tail race water from Power House No. 1 drains

Aluminium from Canada assists in India's newest power project.

ALCAN

ACSR "Kundah"

—the cable that was specially designed as a result of co-operative effort between the Madras State Electricity Board, the Montreal Engineering Company, Ltd. and the Aluminum Company of Canada (ALCAN). This 42/7 ACSR, tailor-made to the specific requirments of the circuit linking the new Kundah hydro-generating station with Madras, is approximately 15% lower in cost than the standard 26/7 design of the same size, due to reduction in the steel reinforcement. Further savings are effected in the cost of the steel towers by the use of the new design.

ALCAN research is constantly bringing the advantages of the light metal aluminium to the world's industries.

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into the Kundah river near the Kundah village, where it is joined by the Kanarahalla and Koulmulihalla streams. A small regulating forebay is erected by building a stone masonry gravity type dam near the Kundah Palam village. This dam is 500 ft. long 95 ft. high and 15 ft. wide at the top. The intake for Plant II is from this small forebay of capacity 55 M. Cft.

Tunnel. II.

The water from the Kundah forebay is taken through another tunnel for a distance of about 12,000 ft. This tunnel has a large cross section than Tunnel I and is of horse shoe shape 11′×11′ with a maximum discharge capacity of 1000 cusecs.

The tunnel commences with low pressure pipe inlaid (a steel lined tunnel) of 11′ 3″ in diameter for a length of about 180 ft. The balance is excavated in rock except for a short reach of about 450 ft. where there is not sufficient rock cover. In this reach steel pipes of diameter 11′-3″ are introduced. The tunnel is lined with cement concrete of thickness varying from 8″ to 12″; where the rock is not very sound 18″ thick R. C. C. lining is adopted. The end portion of the tunnel near the surge tank is again steel pipe line of 11′-3″ diameter for a length of 750 ft.

Surge Shaft.—II

Tunnel II ends in a surge shaft which is 241 ft. deep and partially embedded in rock. This is also R. C. C. lined. It has a diameter of 25′ at the bottom in the rocky region and 50′ at top in the earth portion.

Penstock.—II.

The water from the surge tank is taken through R. C. C. lined tunnel of horse-shoe and circular shapes for a total length of 750 ft. and a steel pipe line of 10′-9″ diameter for a length of 60 feet.

The pipe line below surge shaft end in a manifold bifurcating into 8′-0″ and 6′-6″ diameter pipes. The 8′-0″ diameter pipe ends in a trifurcating manifold connecting three penstock lines, and the 6′-6″ diameter pipe bifurcates into two penstock lines each feeding an independent machine at the Power House. II.

Of the five, one will be blank flanged for connecting up the fifth pipe line at a later date. The penstock pipe each about 5300 ft. long has a capacity of 200 cusecs. These pipes are also made of U.S.T.I. steel and supplied by M/s. Davie Shipbuilding Co. Ltd. The diameter of each pipe line is 57″/51/45″. The thickness of the shell ranges from 5/16″ to 13/16″. The total weight of the 4 pipe lines is about 3034 tons.

POWER PLANT AND TRANSFORMER YARD

The Power House is of structural steel frame with stone masonry. It is built to accommodate five generators ultimately. It is 302′-6″ long, 80 ft. wide and 51′-9″ high above the generator floor.

The generating machinery consists of four multiple jet (3 jets) impulse type vertical turbines of 50,000 H. P. each, at a net head of 2340 ft. and are of Dominion Engineering make. Each turbine is coupled with a 42,000 kVA 0. 9 p. f. 3 phase, 11 kV 50 cycles generator supplied by Canadian General Electric Co. A fifth unit will be added in the third stage works with associated switchgear.

The transformer yard is adjacent to the power station. On account of the difficult terrain, the yard is in two levels. It has two sections, one for the 110 kV and the other for the 230 kV.

In tye 110 kV section there will be four 42,000 kVA 11kV/110kV 3 phase power transformers of C.G.E. make.

A double circuit 110 kV line takes off from this sub-station to Tudialur to link up with the existing 110 kV grid.

The 230 kV section of the yard contains three 50,000 kVA 3 phase 110/230 kV auto transformers, One single circuit 230 kV line takes off from here to Salem, and thence to Villivakkam.

TRANSMISSION LINES AND SUBSTATIONS

The Transmission system comprises 287 miles of 230 kV single circuit line with (42/0.1376 AL+7/0.0764St.) 795,000 C. M. A. C. S. R. conductor and 30 miles of 110 kV. double circuit line with (6.2109 AL+7/0703 St.) 266, 800 C. M. A. C. S. R. conductors. This is the first 230 kV line built in Madras Power Grid.

Carrier communication and relaying is being provided on the 230 kV line. On the 110 kV lines, carrier communiction alone is provided.

The power generated will be fed into the grid at Tudialur, Salem and Villivakkam. The 230 kV system has substations at Salem and Villivakkam with two 50,000 kVA 230/110kV auto transformers. These autos were supplied by M/s. C. G. E. Ltd.

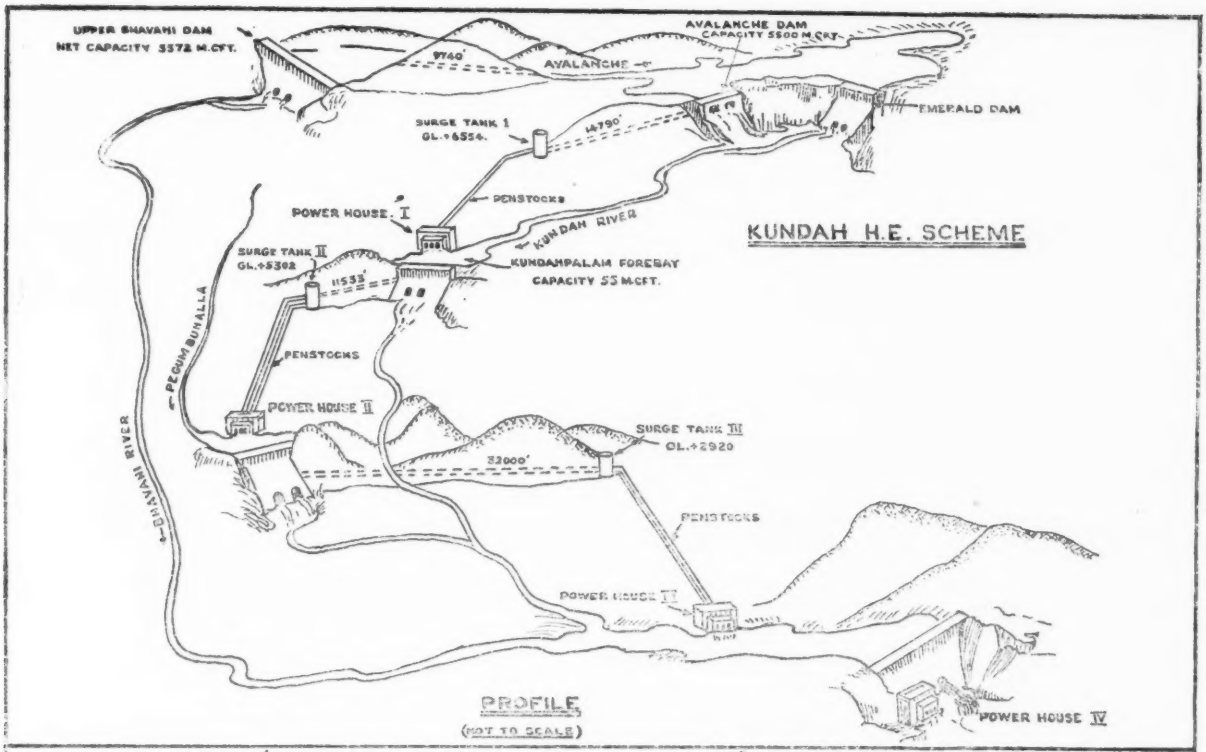
For system stabilisation, a 25 MVAR synchronous condenser of Canadian Westinghouse make is also being installed in the Villivakkam substation.

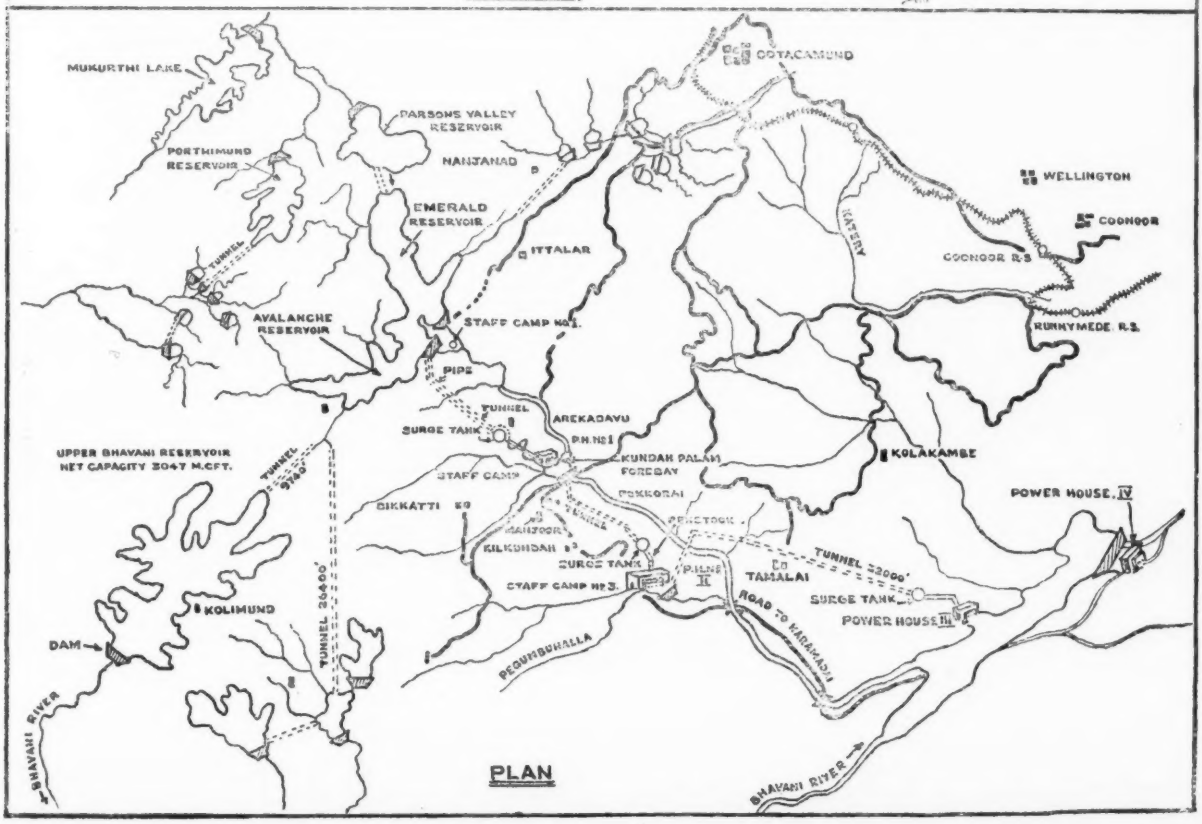
PRESENT PROGRESS OF WORKS

From June 1956, the works are in full swing at the three dam sites, three tunnels, two penstocks and 2 power house sites. All the head works connected with Power House I were completed in a record time of 3½ years. The Plant I is inaugurated now for commercial use. The transmission lines both 110 kV and 230 kV are also ready to transmit this power to the different load centres.

The works connected with Plant II are in progress, and it is expected that the first unit at Plant II will go into operation in July this year. Works are also in progress at the Upper Bhavani Dam site. The initial phase of the scheme is expected to be completed in all its aspects by 1960-61 adding a total installed capacity of 1,80,000 kW to the State Power Grid.

[*Continued on page* 44


UPPER BHAVANI DAM
NET CAPACITY 3378 M.CFT.
AVALANCHE DAM
CAPACITY 5800 M.CFT.
AVALANCHE
EMERALD DAM
SURGE TANK I
GL.+6554.
PENSTOCKS
POWER HOUSE I
KUNDAH RIVER
KUNDAH H.E. SCHEME
SURGE TANK II
GL.+5302
KUNDAMPALAM FOREBAY
CAPACITY 55 M.CFT.
PEGUMBUHALLA
PENSTOCKS
POWER HOUSE II
BHAVANI RIVER
SURGE TANK III
GL.+2920
PENSTOCKS
POWER HOUSE III
POWER HOUSE IV
PROFILE
(NOT TO SCALE)


MUKURTHI LAKE
PARSONS VALLEY RESERVOIR
PORTHIMUND RESERVOIR
NANJANAD
EMERALD RESERVOIR
ITTALAR
AVALANCHE RESERVOIR
STAFF CAMP No 1.
PIPE
TUNNEL
SURGE TANK
AREKADAVU
P.H. No I
KUNDAH PALAM FOREBAY
STAFF CAMP
PORKORAI
PENSTOCK
KILKUNDAH
SURGE TANK
P.H. No II
STAFF CAMP No 3.
TAMALAI
SURGE TANK
POWER HOUSE III
ROAD TO KARAMADAI
PEGUMBUHALLA
BHAVANI RIVER
UPPER BHAVANI RESERVOIR
NET CAPACITY 3047 M.CFT.
TUNNEL 9740'
TUNNEL 26400'
KOLIMUND
DAM
BHAVANI RIVER
COTACAMUND
WELLINGTON
COONOOR
COONOOR R.S.
KATTERY
RUNNYMEDE R.S.
KOLAKAMBE
POWER HOUSE IV
TUNNEL 32000'
PLAN

Construction at Kundah Hydro Electric Project

By L. G. GRANDY

Active construction work at Kundah Hydro Electric Project by the Madras State Electricity Board has been in progress for a little over three and one half years.

By western standard it is a large project. Actually there are two power developments extending over some 6 miles. These developments consist of four masonry dams, two of which are about 200 feet high, one 240 feet high and one 90 feet high.

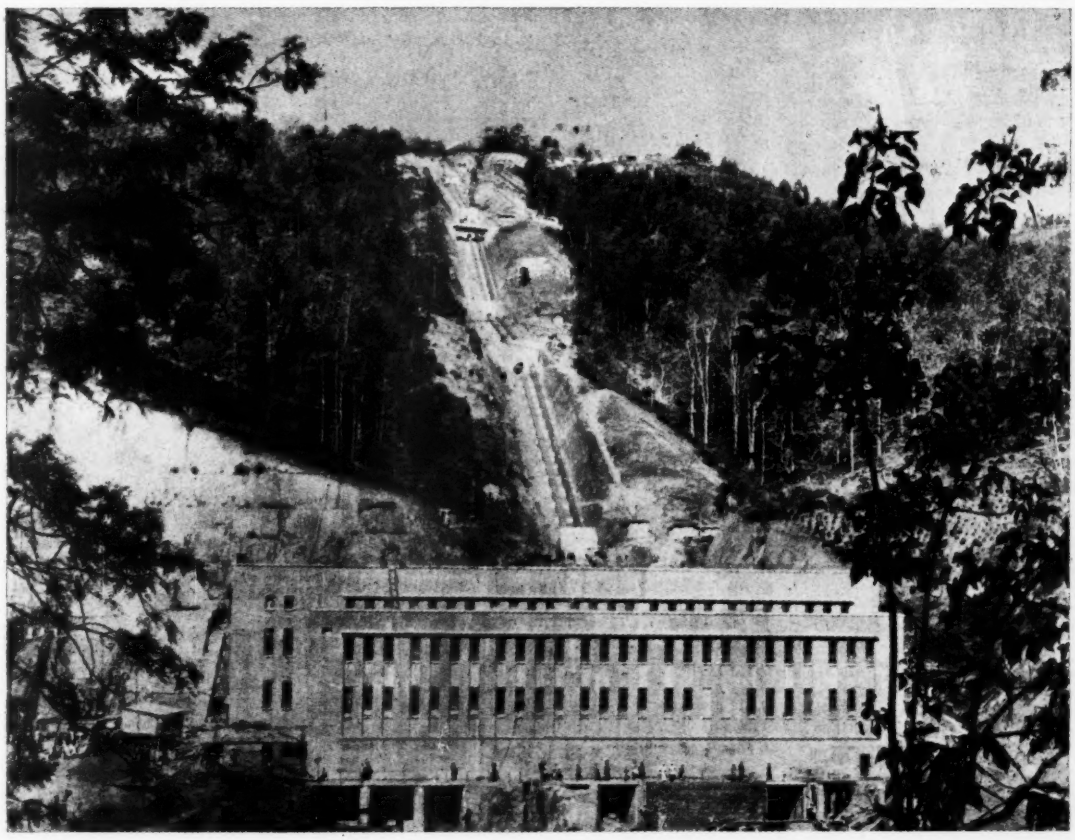
The water stored by the dams will be conducted through a horseshoe shaped pressure tunnel 9 feet 7 in. high some 3 miles long, and thence through two steel penstocks each over 3000 feet long to the number one powerhouse in which will be installed two 20 megawatt vartical impulse turbine generator sets.

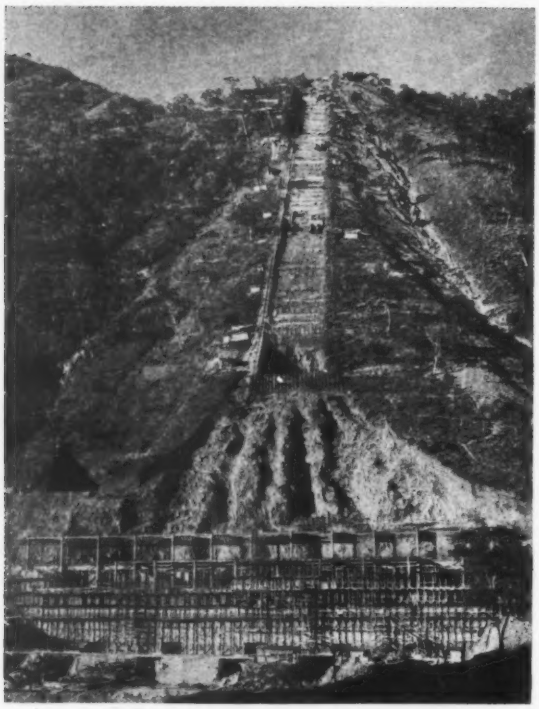
The discharge water from the tailrace of the number one powerhouse will be impounded by 90 feet high masonry dam and conducted through a second horseshoe shape pressure tunnel about 11 feet high some 2 miles long, and thence through four steel penstocks each one mile long to the number two powerhouse in which will be installed four 35 megawatt vertical impulse turbine generator sets.

The whole project is estimated at about 32 crores of rupees. Of this amount Canada is assisting India by suppling hydraulic control equipment, penstocks, powerhouse turbine-generator sets, substation equipment and a 230-kilovolt transmission line from Kundah to Madras, all valued at about 12 crores of rupees.

One of the questions that we as Canadians are most often asked is how the construction methods at Kundah compare with those used in Canada.

Power House 1





Power House II & Penstocks under construction

We believe that the construction of the masonry dams offers the greatest comparison.

The sight that probably amazes and impresses most visitors is the construction method used on these dams. They are of the gravity type and built of hand placed masonry.

Large crowds of workers can be seen moving all over the dams and to the visitor at first sight it looks like a lot of disorganized humanity.

However, after a few questions and a little study one soon sees that each line of workers carrying construction materials, stones and mortar, is moving to specific locations to drop their loads for the masons. Enroute at certain points the carriers are checked off by checkers. Those carrying mortar actually have a tag pinned on their clothes indicating what mix they are carrying. 1:1:3, 1:1:4 etc., The figures refer to proportions of cement, river sand and crushed sand.

Due to the high cost of labour masonry dams have not been built in Canada in quite some years. If these dams were being constructed in Canada today they would probably be of rock and earthfill type if suitable earth fill was available. Otherwise they would be built of concrete. In both of these types, large amounts of heavy construction equipment would be used.

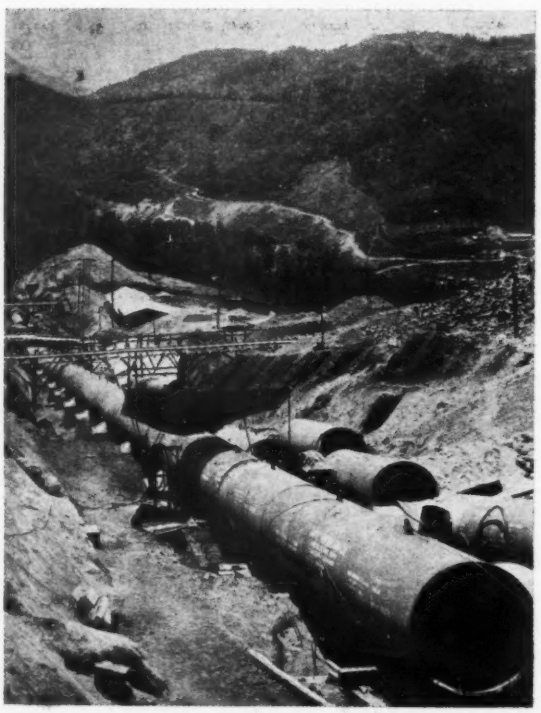
One of these types of dams could probably have been used at Kundah, but it would have deprived thousands of workers of a livelihood. In many cases these workers have been engaged in building similar dams in South India over the past 30 years.

In a land with an abundance of low cost labour and where excellent stone cutters are still to be found, as can be seen by the great temples that are built from intricately and beautifully carved stone, the use of so much skilled and un-skilled labour can only be thought of as humanitarianism at its highest level. In fact it could be thought of as a sort of Colombo-Plan on a national basis.

Although manual labour is used extensively carrying stones and mortar yet there is a side of the dam work that is completely modern. Concrete mixers are used to mix the mortar. These not only help to speed up the work but ensure good quality control. Also, in the stone quarries pneumatic rock drills are used to drill the rock for blasting. The stone spalls not suitable for masonry are used in modern crushing and screening plants to produce sand for the mortar.

After the dams come the tunnels. These tunnels were driven by two experienced contractors and both used construction methods as modern as anything in Canada. Rock drills with airlegs were used throughout. Mucking was done by loading machines and the muck was carried in mine car pulled by diesel mine locomotives. The rock is generally of a very hard dense granite weighing as much as 170 to 180 lbs. per cubic foot. The tunnels are being lined wtih concrete placed both by hand and pneumatic placers.

Penstock II



After the tunnels come the penstocks. The grading and excavating for these were done entirely by hand labour and transported by head loads. Where rock was encountered pneumatic rock drills were used for drilling holes for blasting.

The penstock anchors are of reinforced concrete. Mixers were used throughout and the concrete was transported either by chutes or head loads. In Canada wheel barrows and concrete buggies would have been used extensively for this work.

The erection of the penstocks has generally followed one of the standard methods employed on steep and near steep slopes. Track lines were laid along the slopes adjacent to the penstock routes. Haulage winches were erected at convenient locations. Penstock pipes of 23′-9″ maximum length were transported by tractor trailers to the winch heads and either loaded by ramping or gantry crane on the winchcars. The pipes were then lowered down the slope by the haulage winch and manhandled into position by pull-lifts, chain blocks and jacks.

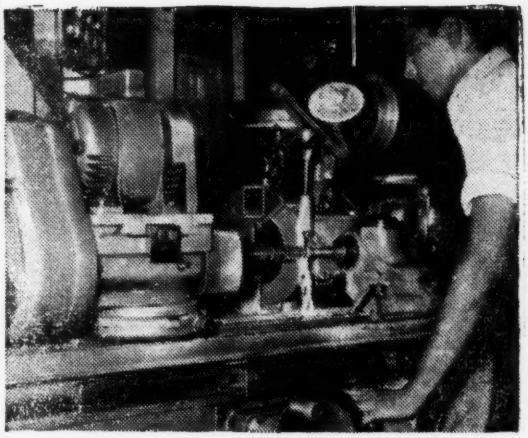
It is interesting to note that the penstock pipes are fabricted of a relatively new very high tensile steel and that this is probably the first installation in Asia. This steel has a minimum yield point of 90,000 p. s. i. and an ultimate strength of 105,000 to 135,000 p. s. i.

The two powerhouses have concrete substructure walls and steel superstructures with masonry walls. In the pouring of the substructure walls concrete mixers were used for mixing but the mix was transported by hand loads. This method of transporting showed up a disadvantage later on when pouring the foundations for the turbines and generators, and the use of mine cars was resorted to. The cars mounted on tracks were filled directly from the mixers, rolled into the powerhouse and picked up by the electrically operated powerhouse crane and carried to the forms. This method led to a speed up in the work and is similar to that used in Canada.

The superstructure steel for the powerhouse was erected by hand winches and gin poles. The gin pole was erected at each lifting point and the members were skidded to the pole and lifted into position. Standard pneumatic rivetting hammers were used. Rivets were heated in hand blower forges but no attempt was made to pitch them. The forges were located as close as possible to the work locations and the hot rivets were placed in cans which were pulled up by a rope to the joint being rivetted. One thing that would amaze Canadian steel riggers would be to see the Indian riggers climbing up the steel columns using only their hands and feet.

For one who has been at Kundah for the past two years it has been a wonderful experience to see the blend of old and new methods of construction, and to see the large working force organized into a working team augmented by the use of modern equipment.

All praise and credit are due to all the Indian engineers and the construction workers associated with the project.



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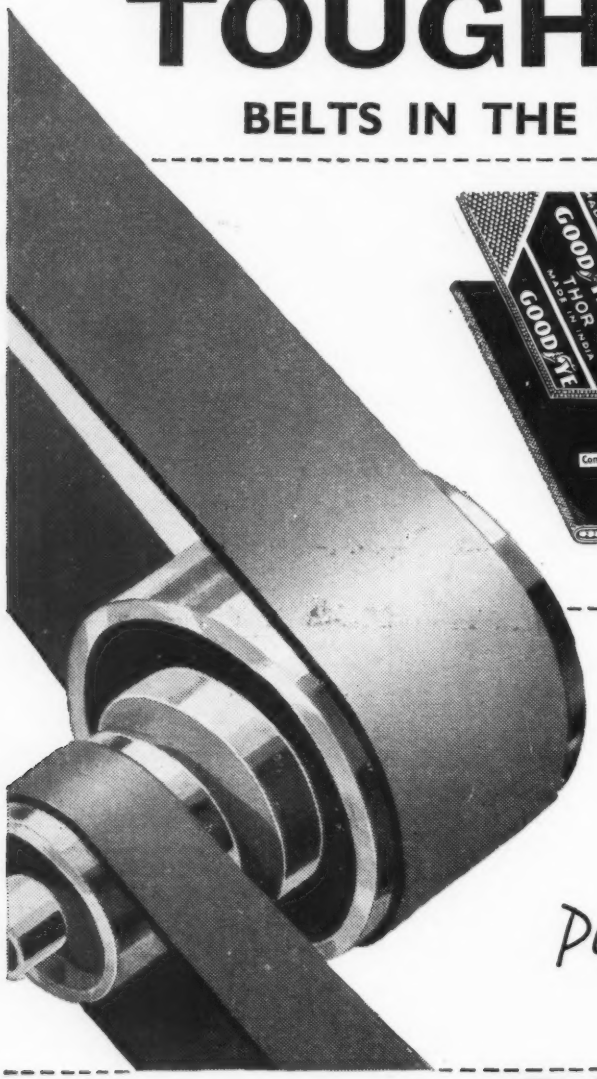

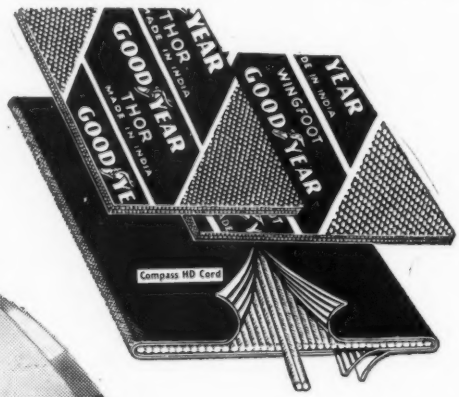

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High Dams in Kundah Project

By R. M. THIRUMALAIKOLUNDU
AND
M. KOTHANDARAMAN

The Kundah Hydro Electric Scheme which is in the Nilgiris is the biggest of the power schemes so far undertaken by the Madras State. The Nilgiris, which has given Ooty, the Queen of hill stations in India, by virtue of its high altitudes with a number of streams having their sources at altitudes between +7000 and +8000 and flowing down to plains of elevation of about +1000, has adapted itself for the construction of several high dams and high head hydro electric projects. The potentialities of Pykara river rising at altitude of +7500 with its other tributories has been practically harnessed by the construction of two power houses, one at Singara and the other at Moyar. The Kundah Hydro Electric Scheme will harness the waters of Upper Bhavani, Avalanche, Emerald, Kundah and several other streams rising at altitudes varying from +7500 to +5300.

RESERVOIRS

Avalanche, Emerald, Upper Bhavani and Kundahpalam are the four reservoirs formed under the present stage of the scheme. Of these, Avalanche, Emerald and Upper Bhavani will serve as regular storage-reservoirs, while Kundahpalam will function as a forebay for regulation purposes. The Avalanche and Emerald reservoirs interconnected by a tunnel through the dividing low ridge form a combined reservoir of capacity (gross) 5500 M. cft. The flood discharge of about 25000 cusecs from the combined catchment will be passed over the spillway provided in the Avalanche dam, the Emerald dam being entirely of non-overflow type. A pressure tunnel for carrying the power discharge of 750 cusecs takes off from the right flank of the Avalanche dam.

The forebay dam is built across Kundah river for intercepting the tail race waters of Power House No. 1 and also the flow from the free catchment of 44 sq. miles. A pressure tunnel for carrying a power draft of 1000 cusecs takes off from the right flank of the dam. The storage from the Upper Bhavani reservoir will be diverted to the Avalanche reservoir through a tunnel, which takes off from the foreshore.

TYPE OF DAMS

All the dams have been designed as straight gravity type. Alternative designs such as earthen dams and arch dams were considered but were ruled out on considerations of cost, construction facilities, completion period etc.

The maximum heights above foundation of all the four dams under construction are:—

Avalanche	..	186 feet
Emerald	..	212 ,,
Upper Bhavani	..	266 ,,
Kundahpalam	..	95 ,,

Except the Kundahpalam dam, all the other dams which are above 150 ft. in height will come under the category of "High dams". Of the above, the Upper Bhavani dam will be the highest so far constructed in South India.

FOUNDATION

The type of rock exposed in all the dam sites generally consists of garnetiferous pyroxene granulites. In Emerald dam site, the rock line rises steeply in the flanks thus facilitating butting of the dam masonry on the rock faces.

In Avalanche dam the rock line rises steeply at the left flank while it runs somewhat flat at the right flank with huge earth cover.

In Kundahpalam dam, the sound rock line is very steep at the right flank while it is practically flat at the left flank with very heavy overburden of earth.

Upper Bhavani dam is under excavation stage. The foundation rock line is steeply rising towards the left flank while in the right flank it is practically flat for some distance from the bed and then gradually rising.

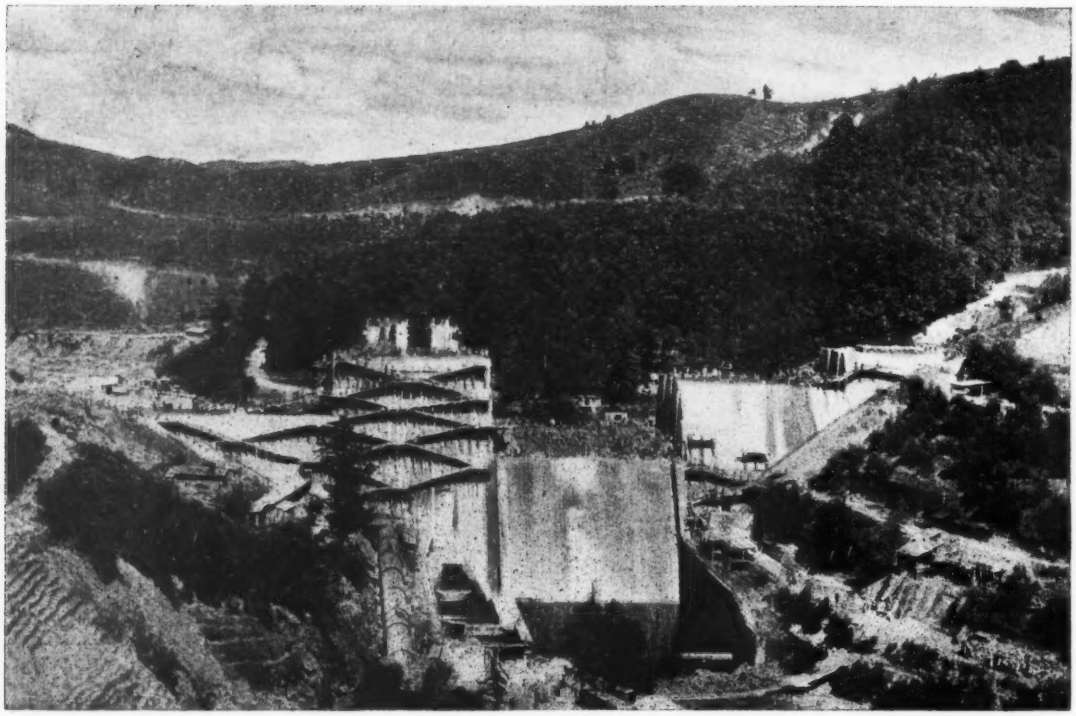
FOUNDATION TREATMENT

The failure of a gravity dam may occur due to:—

(*i*) Overturning
(*ii*) Sliding at foundation level
(*iii*) Uplift in foundation

Normally no failures occur due to overturning but some dams notably Austin, Tex, Austin Pa., The St. Francis etc., in the U. S. A. have failed due to sliding caused on account of uplift pressures on the foundations. Therefore the uplift effects in the foundations are the most important for consideration in a dam design. But every structure is a specific case and there can be no general rules for universal application on the assumptions of uplift in foundation. The treatment done for the dam foundation in Kundah project includes :—

(*a*) Grout curtain or artificial impervious barrier provided in the heel of the dam, by drilling a number of holes at 20 feet intervals and grouting them to refusal under high pressure along the entire length of the dam.



Avalanche Dam

(*b*) Consolidation grouting over the entire area of the foundation where necessary below curtain grout.

(*c*) Longitudinal foundation drains to catch and collect seepage water from the foundation rock and convey it through shafts to the drainage gallery.

(*d*) Drainage holes 3" diameter drilled in the foundation rock after completing all the grouting operations.

(*e*) Special treatment for faulty zones, if any

Grouting Plan:

The empherical formula to determine the depth of curtain hole is given by $d = \frac{h}{3} + C$ where

d = depth of hole
h = height of dam above hole
c = a constant varying from 25 to 75 depending on geological conditions.

One more criterion has been assumed that the holes may be taken to such depths where corresponding rock depth will counteract the depth of water. Assuming weight of rock as 170 lbs. per cft. and water as 62.5 lbs. per cft. and a gradient of 1 in $1\frac{1}{2}$ (in fissured rock say)

$$\left(H + D - \frac{D}{1.5}\right) 62.5 = 170\ D$$

or $62.5H = 149\ D$

or $\frac{D}{H} = 0.42$

The depths of curtain holes actually adopted are given below :—

	Avalanche	*Emerald*	*Kundah-palam*	*Upper Bhavani*
Depth of water in feet	190	200	90	240
$D = \frac{H}{3} + C$	88	90	55	105
$D = 0.42\ H$	80	84	38	100
D adopted in ft.	85	85	54	100

The above depths represent only the first line of curtain holes. The depths of the second and third row of curtain holes have been reduced. In Kundahpalam dam, single row of curtain holes has been driven while in Avalanche and Emerald dams two rows have been driven. Three rows are proposed for Upper Bhavani dam. Besides the above curtain holes, consolidation

grouting has been done in the other areas of the foundation *not* as a matter of rule but wherever necessary depending upon the nature of exposed rock and joints met with. The diameter of holes drilled is 1-3/8". The typical grouting plan adopted for all the dams is illustrated in the figure I.

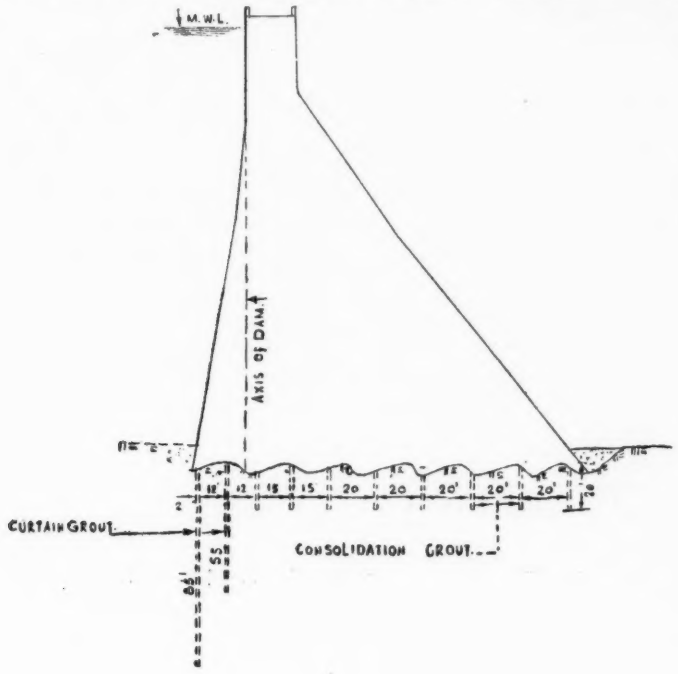
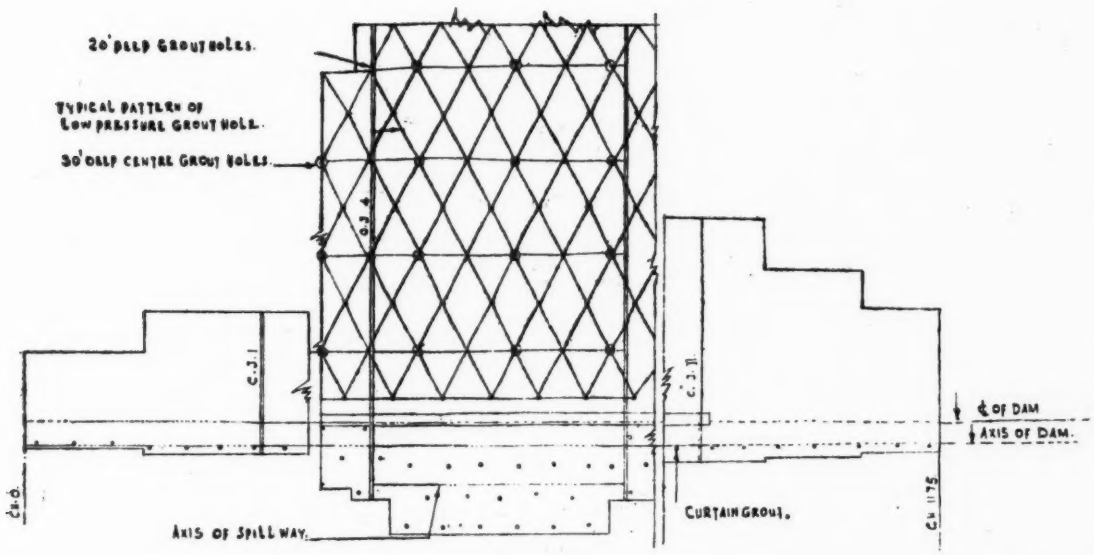


FIG. 1



PATTERN OF GROUT HOLES.

Pressure Grouting

Pressure grouting of foundation is done primarily to eliminate seepage and to reduce to the minimum uplift pressures in the foundation beneath the dam structure. It also arrests deterioration of foundation rock by keeping out the water from the seams which are filled by cement. Grouting also increases the bearing strength of the foundation rock by filling any voids or fissures which may be present. The grouting pressure in all these dams has been limited to 100 lbs/sq. inch for curtain grouting and 50 lbs/sq. inch for consolidation based on similar operations done in Pykara, Tambraparni, Maravakandi, Mukurti, etc.

Grouting and Grout Mixture

(*i*) Grouting has been done after ascertaining the nature of rock and joints by conducting water pressur and air pressure tests into the holes at 50 lbs per sq. inch. The grouting operation has been done with a comparatively thin mix to begin with and gradually increased to a thick mix as the hole tightens.

(*ii*) Grout mixes of 1:2 proportion has been generally adopted for the final grouting but where the rock is loose, a thicker mixture of 1:1½ or even 1:1 has been used.

(*iii*) The foundation rock in all the dams except Upper Bhavani Dam has been grouted and consolidated satisfactorily to the requirements.

DRAINAGE SYSTEM

The drainage system provided in all the dams comprises of drainage of the foundation and internal drainage of the dam masonry. A drainage gallery 5′-0″ wide by 7′-6″ high running practically the entire length of the dam is provided to collect all the leakages through the dam masonry as well as the foundation. Transverse galleries of the same size as the main gallery are also provided to serve as approach to the main gallery and also to lead out the seepage water. Ventilating fan has been provided from the dam top leading to drainage gallery to exhaust the foul air inside the gallery in Kundahpalam dam as there is only one transverse gallery on one flank. Two longitudinal drains 12″ × 18″ are formed directly on the rock foundation. The upstream drain running for the entire length of the dam is located immediately in rear of the impervious masonry. The other drain located at 25 feet downstream extends roughly to cover the river bed. Series of drainage holes 3″ in diameter have been driven beneath the foundation drains. Vertical drainage shafts 9″ diameter are provided at 20 feet centers above foundation drains. The shafts from the upstream drain will directly drain into the main drainage gallery, while the shafts from the downstream drain stopped just above the floor of the main gallery is connected to the main gallery by individual transverse drains. The vertical shafts have been formed in the dam masonry from the roof of the main drainage gallery to the dam top to accomplish the internal drainage.

The figure II illustrates the typical arrangement of the drainage system provided in all the dams under construction.

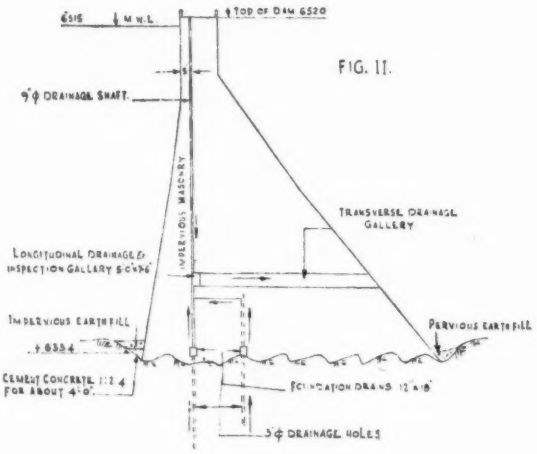


FIG. II.

DRAINAGE ARRANGEMENTS.

DESIGN ASSUMPTIONS

(*a*) *Weight of masonry*

150 lbs. per c.ft. has been assumed as the weight of dam masonry based on the results of the tests conducted on masonry blocks of size one cubic yard .

(*b*) *Compressive stress*

The following maximum stresses have been allowed in determining the safe and economical profile for adoption.

Name of Dam	*Maximum height above the deepest foundation level in feet.*	*Maximum stress in Ton in S.ft.*
Upper Bhavani	266	16.8
Emerald	212	15.4
Avalanche	186	13.4
Kundahpalam	95	9.4

(*c*) *Co-efficient of static friction*

Though the standard value is 0.75, higher values, say upto 1.0, have been allowed in the deep portions of the high dams provided the shear friction factor of safety is not less than 5.

(*d*) *Overturning moment*

Factor of safety against overtunring moment has been maintained as not less than 1.5

(*e*) *Uplift pressure*

The foundations as exposed and the details of the core bores drilled in all the dams revealed the following:—

(*i*) The rock below the foundation level of Kundahpalam dam had comparatively a number of weak zones and quite a large number of vertical and horizontal joints;

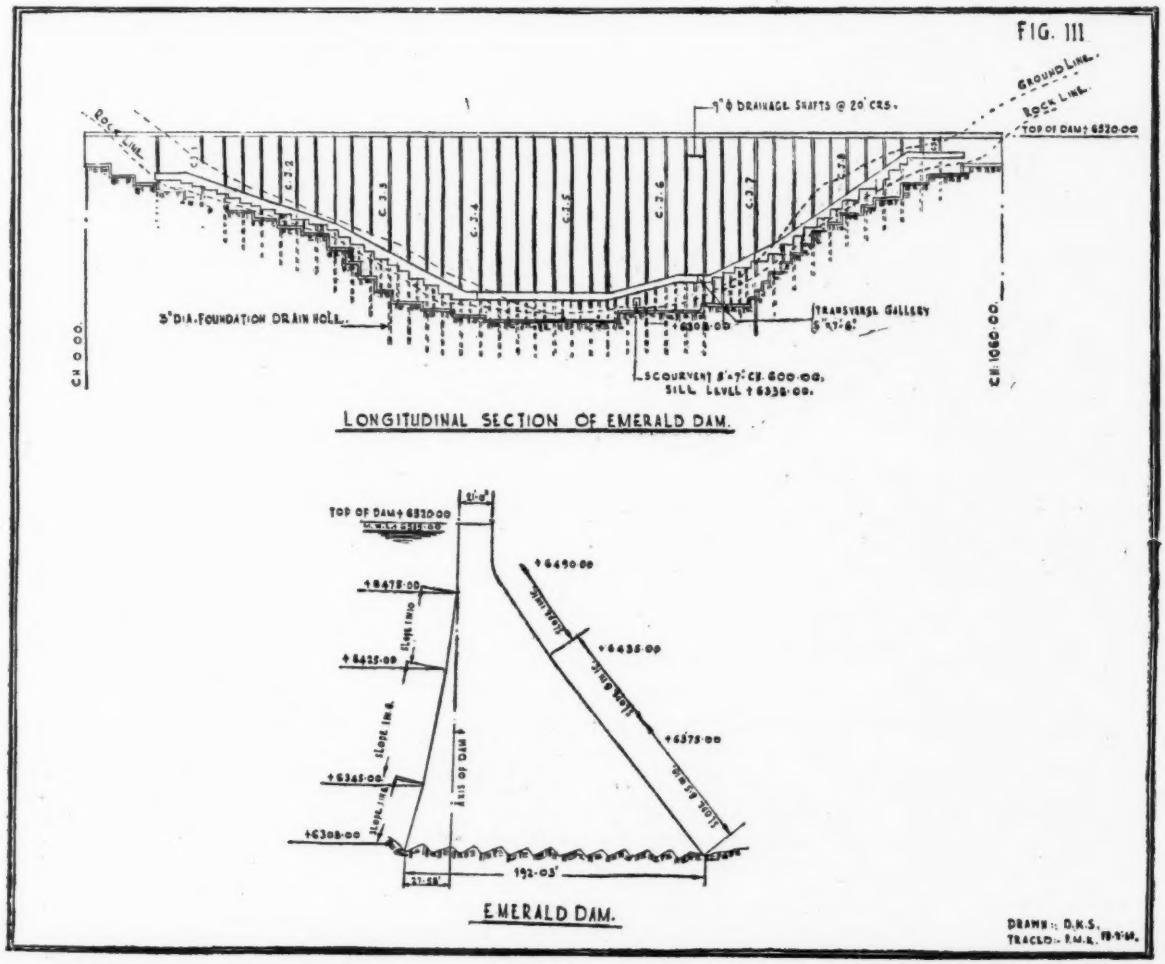
(*ii*) There were quite a large number of permeable or weak zones in Avalanche and Emerald dams also and some shattered zones in Emerald dam. However the quality of foundation rock were considered sound being free from joints.

In view of the conditions of the foundation rock available, the following uplift pressures were assumed in designing the dam profiles.

Name of dams	*Uplift pressures*
(*i*) Avalanche & Emerald	100%@heel, 50%@drainage line and zero @ toe.
(*ii*) Kundahpalam	100% @ heel, 66-2/3%@ drainage line and zero @ toe
(*iii*) Upper Bhavani	100% @heel, 50% @ drainage line and zero @ toe.

(*f*) *Silt.* Kundah river carries heavy silt and so Kundahpalam dam has been designed for silt laden water of weight 100 lbs/cft.

The pofile and L. S. of the dams are shown in figure III and their salient features are given in the statement.



Salient Features of Dams

Description	*Avalanche*	*Emerald*	*Kundah Palam*	*Upper Bhavani*
1. Length of Dam in feet	1175	1060	500	1400
2. Top level of Dam	+6520	+6520	+5335	+7476
3. Deepest foundation level	+6334	+6308	+5240	+7210 (probable)
4. Top width in feet	21	21	15	21
5. Maximum Height	186	212	95	266
6. M. W. L. & F. R. L.	+6515	+6515	+5330	+7470
7. Minimum Draw-down level	+6375	+6375	+5280	+7380
8. Capacity in Million cubic feet: Gross:	5537	5537	62	3570
Net:		5437	56	2870
9. Catchment area in sq. miles		25	44	12.8
10. Maximum flood discharge		25,000 c/s	55,000 c/s	16, 500c/s
11. Length of spillway in feet	80	No spillway	80	50
12. Crest level of spillway	+6495	—	+5300	+7450
13. Number and size of spillway gates	2 Nos. 40′×20′	—	2 Nos. 40′×30′	2 Nos. 25′×20′
14. Sill level of Intake	+6360	—	+5278.75	+7365
15. Diameter of Tunnel Intake	10′-0″	—	11′-3″	6′-6″
16. Size of Intake gates:				
(*a*) Regular gate:	10′-0″×10′-0″	Nil	11′-3″×11′-3″	Nil
(*b*) Emergency gate:	10′-0″×13′-2″	Nil	11′-3″×14′-9″	Nil
17. Size of Intake Screens	15′×90′	Nil	22′×40′	Nil
18. Discharge through Intake Pipe:	750 c/s	—	1000 c/s	250 c/s
19. Size of Scourvent	5′×7′	5′×7′	8′×12′	5′×7′
20. Sill level of scourvent	+6350	+6336	+5246	+7290
21. Size of Scour gates:				
(*a*) Regular:	5′-0″×7′-0″	5′-0″×7′-0″	8′-0″×12′-0″	5′-0″×7′-0″
(*b*) Emergency:	5′-0″×9′-2″	5′-0″×9′-2″	8′-0″×15′-8″	5′-0″×9′-2″
22. Size of screens in front of scourvent:	10′×40′ 4 Nos.	10′×40′ 4 Nos.	10′×40′ 4 Nos.	10′×40′ 4 Nos.
23. Total quantity of Masonry:	110,300 units	116,750 units	14,470 units	165,300 units

SPILLWAYS

(*a*) Of all the spillways under construction, Kundahpalam dam spillway requires special mention. The spillway has two vents of 40′×30′ each. 30 feet head over crest in a spillway height of 60 feet is the first of its kind so far constructed in South India.

(*b*) The prime considerations for a high crest gate in a low dam are:—

(*i*) Restricted length to accommodate the spillway in a dam length of about 500 feet besides scourvent and inclined intake.

(*ii*) Due to large quantity of silt accumulating at the dam site and considering the small storage of the forebay of shallow depth, it was considered expedient to keep the crest of spillway as low as possible and the crest gate as high as possible. By this arrangement, the storage above the crest amounting to over 65% of the total storage will be let out during high floods (thereby avoiding deposition of silt) in the reservoir.

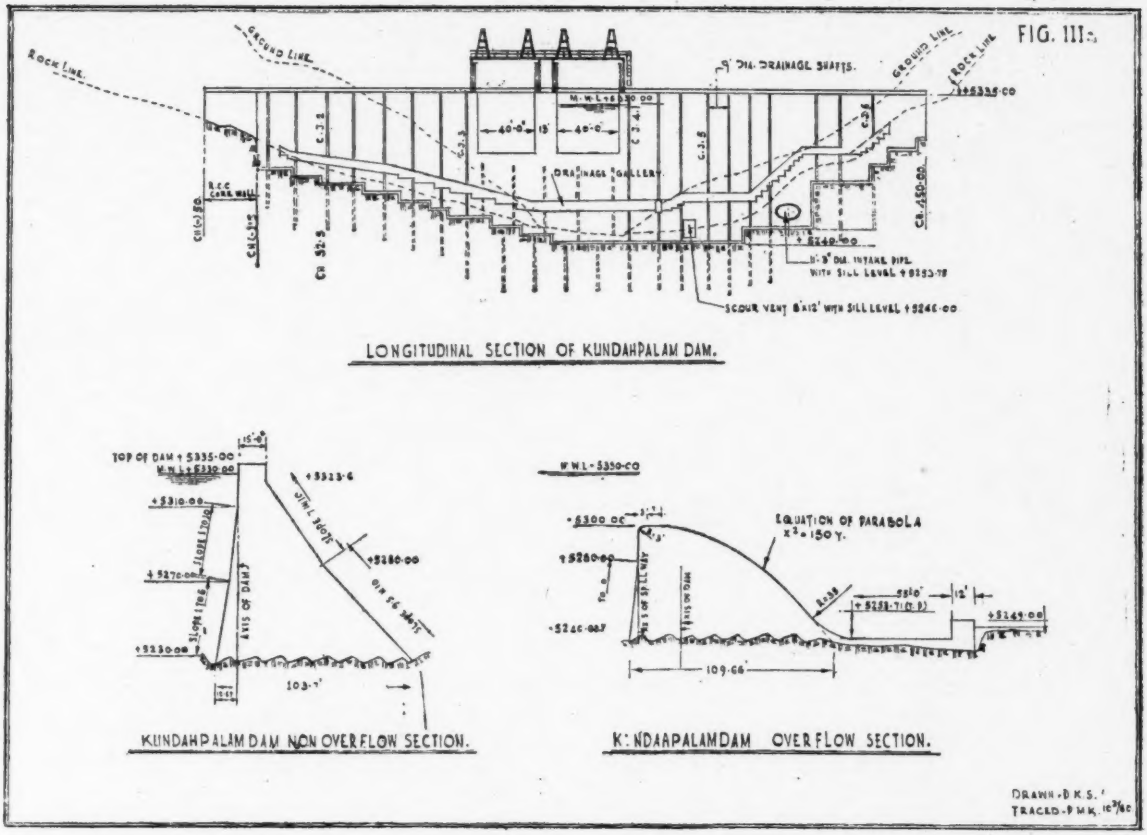
(*c*) The heavy depth of flow over the crest of a short spillway has necessitated a dam profile with broad crest heavy masonry at top and flat slope in rear due to the following considerations:—

(1) Model experiments conducted at the research station on several alternative profiles showed that the falling sheet of water hugs the masonry without developing any undue negative pressures, and (2) to restrict the height of tension zone to the extent possible.

INTAKE

The tunnel intakes taking off from Avalanche and Kundahpalam dams are controlled by a set of emergency and regular gates operated by the hoisting equipments provided at dam top. Fine screens of fixed type are provided. Air vent pipes are fitted in the intake piece to avoid cavitation. Transition at entry is of full mouth shape given at top only. The sill of the tunnel intakes has been fixed so as to ensure a water seal of not less than 10 feet under all conditions and also to utilise the stored water to the minimum reducing the dead storage as far as possible.

FIG. III.


ROCK LINE
GROUND LINE
DRAINAGE GALLERY
SCOUR VENT 8'x12' WITH SILL LEVEL +9246·00
LONGITUDINAL SECTION OF KUNDAHPALAM DAM.
TOP OF DAM +5335·00
AXIS OF DAM
KUNDAHPALAM DAM NON OVER FLOW SECTION.
EQUATION OF PARABOLA
x² = 150 y.
KUNDAHPALAM DAM OVER FLOW SECTION.
DRAWN - B K S.
TRACED - P M K.

SCOUR VENT

While a uniform size of 5′-0″ wide by 7′-0″ deep is provided in Avalanche, Emerald and Upper Bhavani Dams, a larger size of 8′-0″ × 12′-0″ is provided in Kundahpalam forebay dam, as Kundah river carries heavy silt including rolling silt.

Scour Vent: In Avalanche, Emerald and Kundahpalam dams, the scourvent has been formed with sill at about 10 to 20 ft. above the river bed as per normal practice. But in Upper Bhavani Dam, it is proposed to form the scour vent with sill at a higher level of +7290 against river bed level of about +7220 for the following reasons :—

(*i*) Upper Bhavani river does *not* carry heavy silt. The main function of the scourvent is to deplete the storage in the reservoir so as to facilitate inspection of the tunnel intake when required as the sill level of the scourvent is +7290 while the sill of the intake is +7365.

(*ii*) Considerable saving in the cost of gates, embedded parts, hoisting machinery and concreting the gate chamber by forming the scourvent at as high a level as possible.

Construction vent: Normally in dam constructions, the scourvent will be utilised as a construction vent after the dam is raised above coffer dam. In the Upper Bhavani dam the scourvent being about 70 feet above the river bed, a construction vent with necessary control has been proposed in the dam masonry with sill at about +7230 in order to facilitate the discharge of summer flows and construction of dam till the masonry level reaches the regular scourvent. This will be plugged effectively after its purpose is over.

TRASH RACK STRUCTURES

Semi-circular trash rack structures have been formed in R. C. C. in front of all the scour vents in order to ensure a large area of waterway through the screen. The R. C. C. structures have been designed for the difference in water pressure due to chockage in the screen. The pressures assumed in the design are:—

(*i*) Top slab and top ring beam 30 ft of differential head;

(*ii*) Column and arch rib 40 ft. of differential head.

MODEL STUDIES

Model studies have been conducted in the Research Station on the following aspects :—

(*i*) Pressure studies for the spillway sections

(*ii*) The suitability of the co-efficient of discharge assumed in the design of spillway.

(*iii*) Energy dissipating arrangements in rear of spillway and scourvents.

As good rocky bed is invariably available in all the river beds, elaborate energy dissipation and rear protection arrangements are *not* provided.

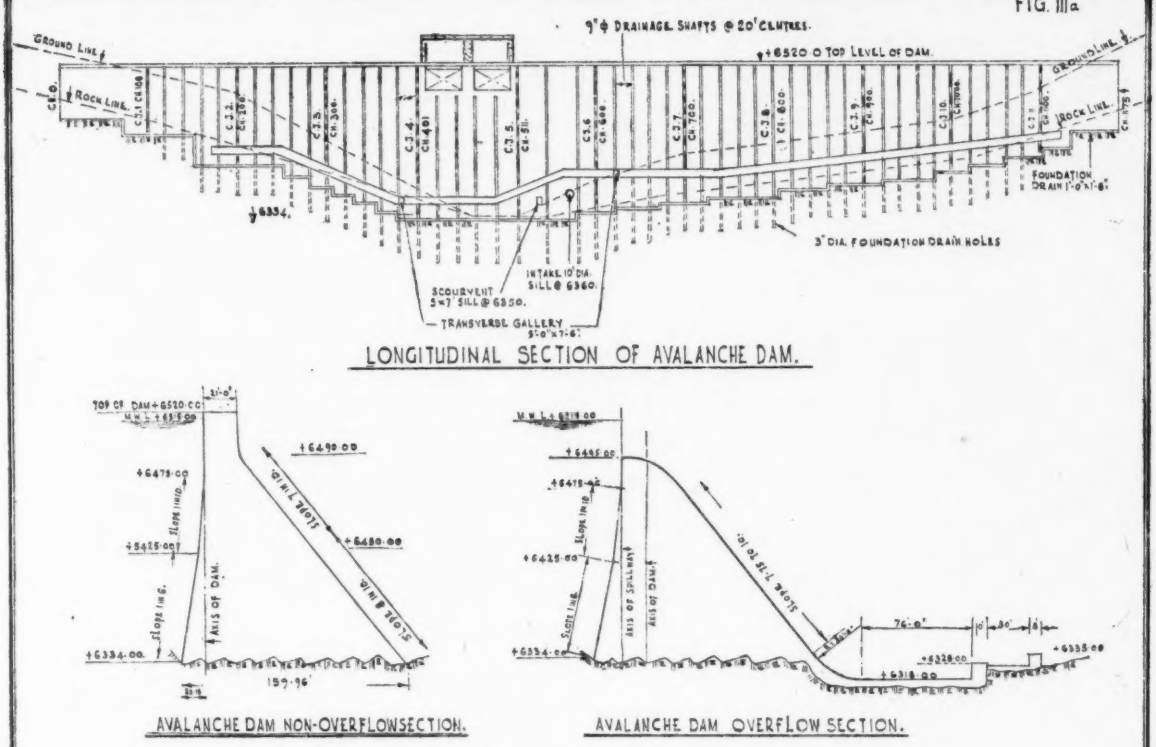
GATES

The crest gates for the spill ways and the cut off gates and screens for the scour and intake of the tunnel with all accessories and hoisting equipment with necessary supporting structures have all been supplied by Canada under Canadian Aid. The technical features of the gates and screens are given below.

Technical Features of Gates and Screens

	Cut off Gates	*Screens*	*Spillway Gates*
1. Type	Regular gates: Roller Type; Emergency gates: sliding type.	Fixed type. Fine screens for intakes. Coarse screens for scourvents.	Raising type of lift gate.
	Designed for full static head. Wind pressure over superstructure 30 lbs/s ft. External pressure on intake pieces 21.5 lbs/sq. in.	Designed for 20′ differential water head. Clear water passage of $2\frac{1}{2}$″ between bars in fine screens and 6″ c/c of bars in coarse screens.	Designed for full static head. Wind pressure on superstructure 40 Lbs/s. ft. Design Stresses: Gate structure. 18,000 lbs/sq in.
2. Design & construction features	Design stresses: Regular Gates 18,000 Lbs/Sq in. Emergency gates: 21,000 lbs/sq in. Intake pieces: 18,000 lbs/sq. in.	Stress: 20,000 p.s.i. Velocity of water=0.56 fps.	Supersturcture; 26,600 Lbs/sq. in
3. Minimum Thickness.	Plates: $\frac{5''}{16}$	Bars: $\frac{7''}{16}$	Plates: $\frac{5''}{16}$
4. Nature of Steel.	ASTM-A-7-55T	U.S.S.Corb Tension Steel	ASTM-A-7-55T
5. Sealing arrangements.	Replaceable flat rubber strip around gate		Brass pipes and hand rolled bronze rods.
6. Lifting Arrangements.	Wire rope of single lug. Electric Motor and emergency hand drive.		Wire rope of improved flow steel hoist for Avalanche and screw stem for Kundahpalam Electric Motor and emergency hand drive unit.
7. Speed of lifting:	Lowering speed: 10 f.p.m. Hosting speed: 4 to 5 f.p.m.	—	2 to 3 f. p. m.
8. Painting	Tenax-As-366	Epoxy red lead primer	Tenax-As-366
9. Special:	(i) Model tests conducted in connexion with shape, air requirements and freedom from vibration. (ii) Emergency gate fitted with filler valve to ensure lifting of gates under balanced condition		Combined airvents and splitters built on gates to prevent formation of vacuum in rear of gates when flood overflows the gate.

FIG. III a



ECONOMY IN CEMENT

Though the dams are built in cement mortar, the feasibility of adopting red cement mortar and lime surki has been examined to effect economy in cement. Manufacture of surki to the requirements of all the dams economically was not feasible due to long and heavy rainy seasons and weather conditions in the project areas.

Lime surki is normally recommended for dams less than 100 feet in height, like Kundahpalam forebay dam. But this is very small in length containing all appurtenent works like spillway, scourvent and intake etc. where cement mortar alone is to be used for masonry and concrete. So, the portion of the dam which could be built in lime surki mortar was *not* appreciable. Besides, the availability of good lime in the vicinity, setting time of lime surki and climatic conditions were against the adoption of lime surki.

SAND FOR MORTAR

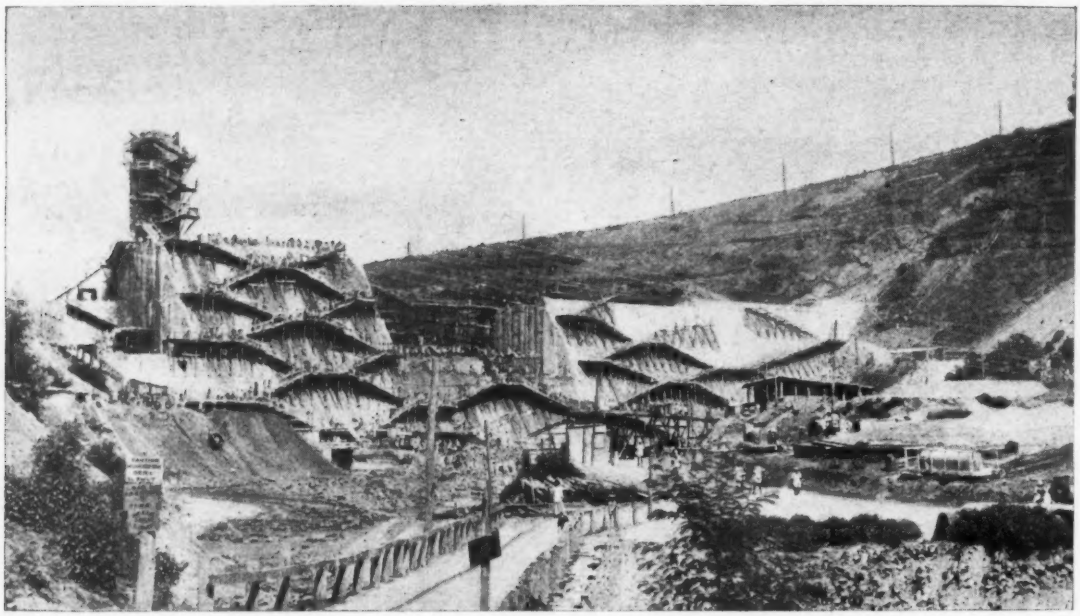
The nearest source of river sand is in Mettupalayam which is about 40 to 50 miles from the dam sites and therefore has been proved very costly for dam works. Further during the peak period of construction in all the dams simultaneously the transport of the river sand to meet the demand will become a bottleneck. Therefore, crushed sand is adopted for mortar with the advantage of the past experience of this department on the adoption of crushed sand for dam construc- tion.

Crushed sand besides being considerably cheaper and readily made available at site to the requirement increases the strength of the mortar by virtue of its higher density and crushing strength thereby assuring better stability of dam. Extensive use of the crushed sand in this department and experiments conducted from time to time have established the following result.

(*i*) The weight of crushed sand per c.ft. is 103 lbs. which is heavier than that of river sand.

(*ii*) The weight of masonry with crushed sand is conservatively assumed as 150 lbs/c.ft. as detailed below:—

Weight of 1 c.ft. of crushed sand as found at Tambraparani dam.	103	lbs/cft.
25% cement @ 90 lbs/cft.	22½	,,
Assuming 10% for shrinkage weight 9/10 c. ft. of C. M. (1:4)	125½	,,



Emerald Dam

Therefore weight of one cft. of well set C.M. (1:4): $= 125\frac{1}{2} \times \frac{10}{9}$

$= 139.4$ lbs.

Average weight of stone of bigger samples. $= 179$ lbs/cft.

With 48% mortar the weight of one cft. of stone masonry works out $(139.4 \times 0.48) + (179 \times 0.52)$
$= 67 + 93 = 160$ lbs.

However a value of 150 lbs/cft. is assumed in the design allowing for variations in samples and other aspects. This is against a value of 140 lbs/cft. assumed for masonry in river sand.

(*iii*) The crushing strength of crushed sand is greater than that of river sand by about 10%

(*iv*) Admixture of a small percentage of river sand is necessary for good workability.

The crushed sand is crushed only from spalls of good granite and other suitable hard variety of stones conforming to specification for building stones. The analysis generally followed in this department based on the observations made at Thambraparni dam are given here.

	Precentage by weight	
	Average sand	*crushed River sand*
1. Passing through sieve with 72 mesh to inch	10.0%	3%
2. -do- 25 -do-	20.0%	26%
3. -do- 8 -do-	45.0%	94%
4. -do- 4 -do-	90.0%	100%
5. -do- 2 -do-	100.0%	—

Cost of crushed sand manufactured by the department at site works out to about Rs. 55/- per unit of 100 cft. while that of river sand varies from Rs. 65/- to 75/- depending upon the lead to the different dam sites. Therefore considerable amount of saving is expected by the adoption of crushed sand in place of river sand.

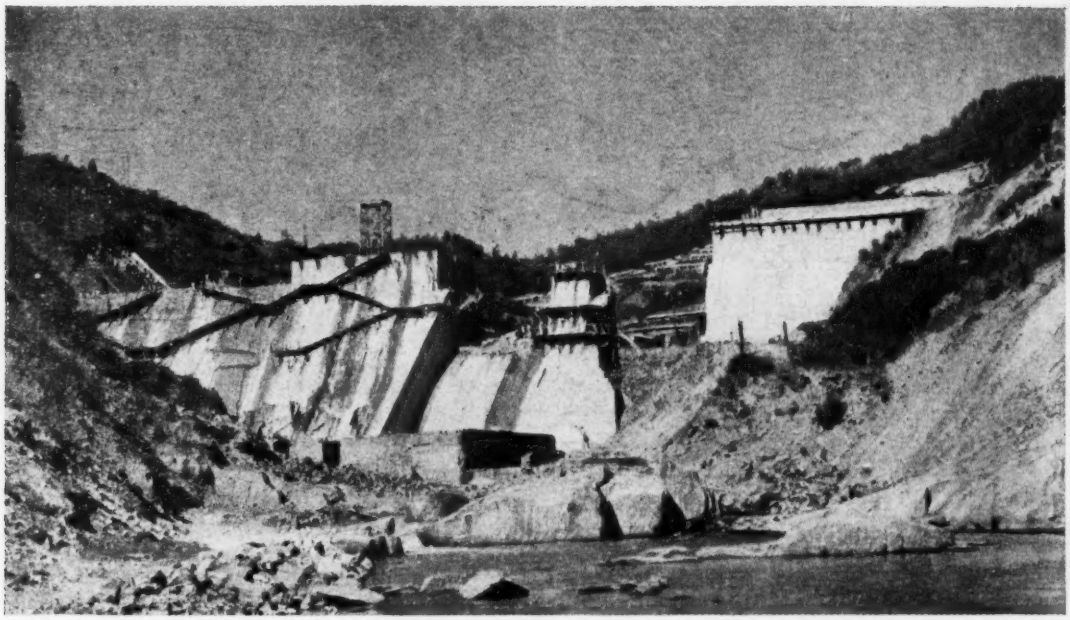
MORTAR

Workability:—The use of crushed sand alone will limit the proportion to 1:4, as beyond this it has been found that the workability gets much reduced resulting in porous and permeable mortar. Therefore both from point of view of ultimate economy and good workability admixture of river sand in a small proportion is made in all mortar mixes.

Proportions of mortar

The limiting factor in stone masonry is mainly the strength of the mortar used and so mortar proportions have been decided for adoption only after a study of tests conducted on large number of 4" mortar cubes. Typical test results of the standard mixes mostly adopted for construction are as given below:

Cement	*Proportion* *Riversand*	*Crushed sand*	*Compressive strength in tons/sq ft.*
1	$\frac{1}{2}$	3	250
1	1	3	182
1	1	4	146
1	1	5	110



Kundahpalam Dam

A factor of safety of about *ten* has been adopted in determining the allowable stress in mortar. The proportions 1: ½: 3 and 1: 1: 5 are considered as the richest and leanest mixes respectively. The rich mix of 1: ½: 3 is generally adopted for about 5 feet depth in the deepest portion of the dam over the foundation rock respective of the stress consideration.

Impervious mortar

The impervious zones of the dam sections have been built with a proportion of 1:1:3 which has been tested and found reasonably impermeable. 1:1:4 proportion is adopted for heating and 1:1:3 for the rear face of the surplus course.

Percentage of mortar

Tambraparni dam of Papanasam Hdydro Electric Scheme was the maiden high dam at that time constructed by this department and the mortar consumption was 47.6%. In dams constructed subsequently, like Pykara, Maravakandi etc., the same quantity of mortar was consumed. Therefore 48% mortar has been maintained as the maximum limit and all efforts are being taken to keep the mortar consumption below this limit.

MASONRY

The following are the approximate quantities of masonry involved in each of the four dams:—

Name of dam	*Quantity of masonry in units of* 100 *cft.*
Avalanche	110,000
Emerald	117,000
Upper Bhavani	128,000
Kundahpalam	45,000

GROUT

Non-shrink grout

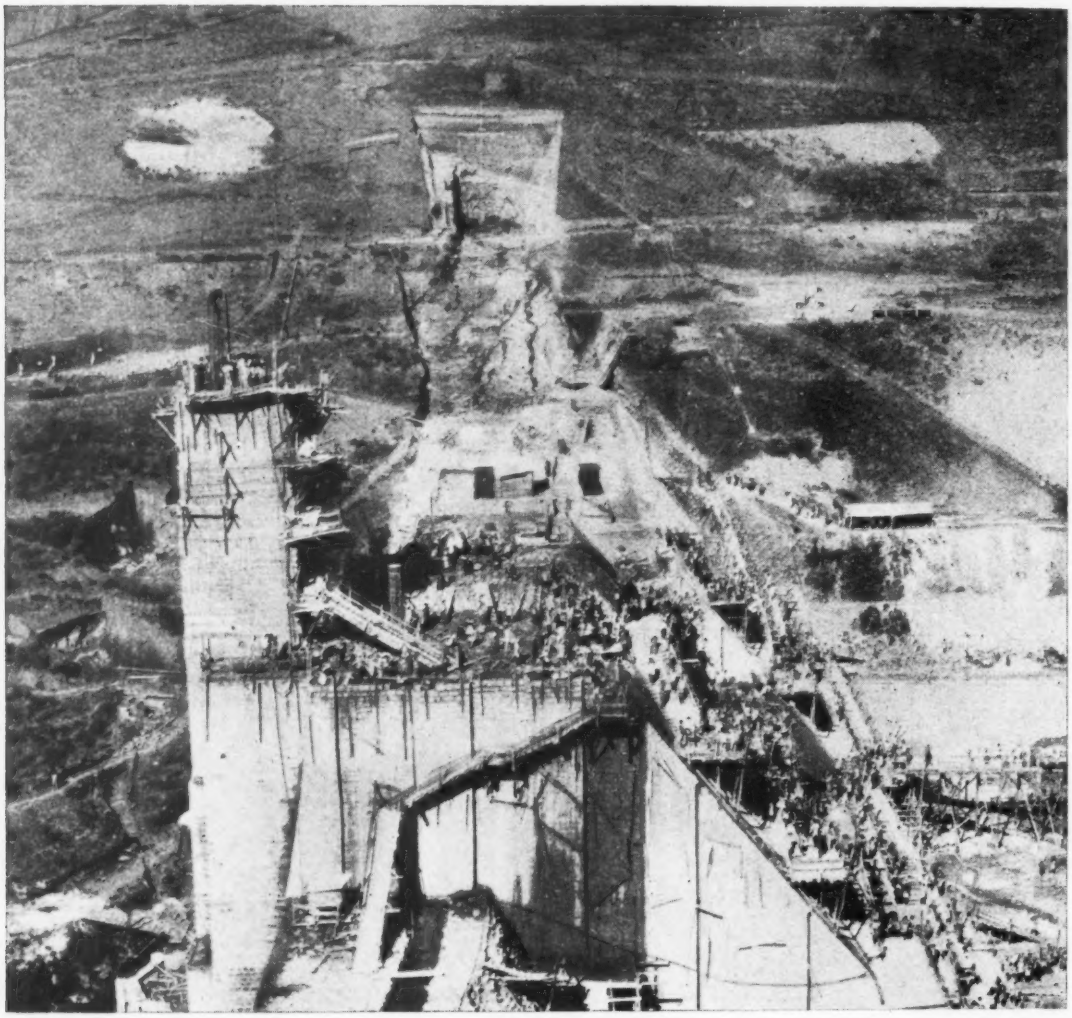
Considerable quantity of concrete grout is done around the openings in dams. Special precaution has been taken to guard against undue shrinkage of the grout concrete by the adoption of "non-shrink grout". Two grams of aluminium powder are added per bag of cement used in concrete. This works out cheap and easy to apply. The Aluminium powder reacts with the basic components of cement to form hydrogen thus causing a volume increase. The minute bubbles of gas help to prevent undue settlement shrinkage. This process has been extensively used with success in Canada.

CORE WALL & REDUCED SECTION

R.C.C. diaphragm wall and reduced section in dam profiles have been adopted in the flanks for economy wherever site conditions permit.

R. C. C. diaphragm wall

The left flank of Kundahpalam dam has got high overburden of earth. Ground contours are steeply rising from chainage zero towards left flank above the top level of dam. Foundation rock line runs somewhat flat in this region. . . . . and it would therefore be uneconomical to build the regular bulkhead entirely inside the earth mound especially when the depth of water is very small. So, the masonry bulk head section has been curtailed at chainage 15 and R. C. C. diaphragm wall constructed from chainage 15 to chainage 50 for economy. The extremity of diaphragm wall has been taken to a length beyond the intersection of the saturation line and the foundation rock line.



Emerald Dam

Reduced Section:

On the right flank of Avalanche dam, the depth of overburden of earth and boulders over hard foundation rock is enormous and is found to vary from 60 to 80 ft. The rock line runs about 120 feet below top of dam almost horizontally for a distance of about 100 ft. from chainage 900 to chainage 1000 and then rises very gradually at a slope of 1 in 3. Because of the considerable depth of foundation rock, major portion of masonry to be built in this reach will be burried in earth. So, for economy in masonry consistent with safety the regular profile of the bulkhead has been curtailed at chainage 900 and beyond reduced section adopted upto chainage 1175. The transition from regular profile to the reduced section has been formed between chainage 900 and 950. By taking the reduced section upto chainage 1175 in the flank, the probable saturation line in rear of dam does not emerge out the rear ground but leads to the river course. The other considerations for adopting reduced sections are,

(*i*) The foundation rock is found to rise in the rear of the dam and hence the restricted or reduced section will have an ideal foundation affording maximum friction against sliding;

(*ii*) Regarding the stability of reduced section, the well-compacted earthfill in the rear will adequately compensate for the reduction of restriction in the area of the dam section.

(*iii*) The restricted section will be well drained with foundation drains and masonry drainage shafts and so there will not be any risk of seepage water percolating below the foundation and scouring the rear portion.

. [*Continued on page* 17

Erection of Penstock No. I

By G. T. ARASU

In the present stage of construction there will be two penstocks to Power House I connected to two individual turbines. The length of the penstock for each line is about 2,900 feet, capable of discharging a maximum of 250 cusecs.

The diameter of penstocks is stepped in three reaches with a diameter of 5′-3″ from manifold i.e. anchor 7 to anchor 5, 4′-9″ from anchor 5 to anchor 2 and 4′-3″ from anchor 2 to terminal anchor. The pipes are spaced centre to centre in the present stage of construction.

FIXING UP OF ALIGNMENT

Before the final alignment of the penstock pipes is fixed, the site has to be examined in detail with regard to the nature of the terrain and its suitability for the construction of anchors.

For fixing up the alignment of penstock line survey was done first and a profile showing the penstock alignment was prepared giving full details of spot levels, L. S. along the penstock alignment, C. S. etc. Then the alignment was finalised. The alignent and fixing the position of the anchors of the penstock was taken up early in 1957 and its grading a little while later. The grading was nearly complete by March '58 except in a few places where grading could not be taken up due to difficulties in getting possession of the required land to proceed with the work. These lands were obtained later on with considerable difficulty and the erection of winches was taken up in June 1958.

The entire penstock alignment is in cutting except in the valley portion between ch. 2950 to 3950 where it is not in cutting and this was unavoidable. It was noticed that if the formation was brought down by about 4′ to 5′ the grading in the other reaches involved heavy cutting and hence the valley was not depressed and it was decided to have the supporting piers down, deep in the hard soil in this reach. The safe bearing pressure on the soil was assumed to be 1 ton per sq. ft.

Fixing up the alignment and levels of the various bends involves very accurate surveying work and required constant check to avoid serious errors cropping up.

PROFILE

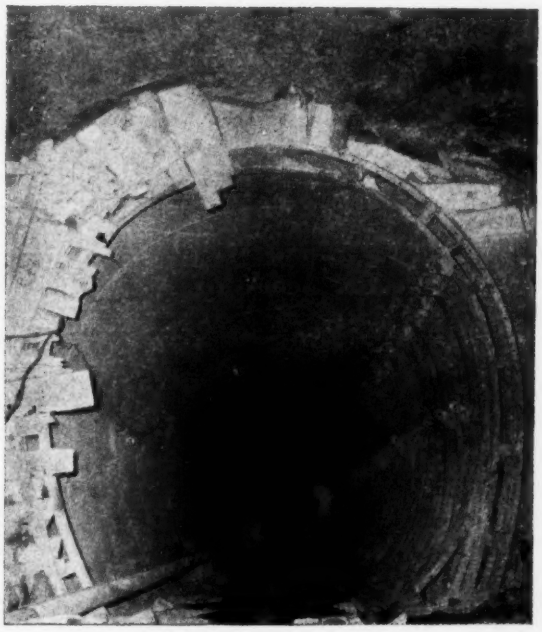
The terminal anchor chainage was fixed with reference to the U.S. side of outer wall of Power House I on the penstock side, which is about 35′-0″. From valve house to terminal anchor there is only one horizontal angle of 3°-57′-23″ at anchor 5 (i.e.) at ch. 2050. The maximum vertical angle in the alignment is 23°-33′-20″ at anchor 4 (i.e.) ch. 2530. The minimum vertical angle is 11°-7′-0″ at anchor 1 (i.e.) at ch. 3700. terminal anchor is at ch. 4092.

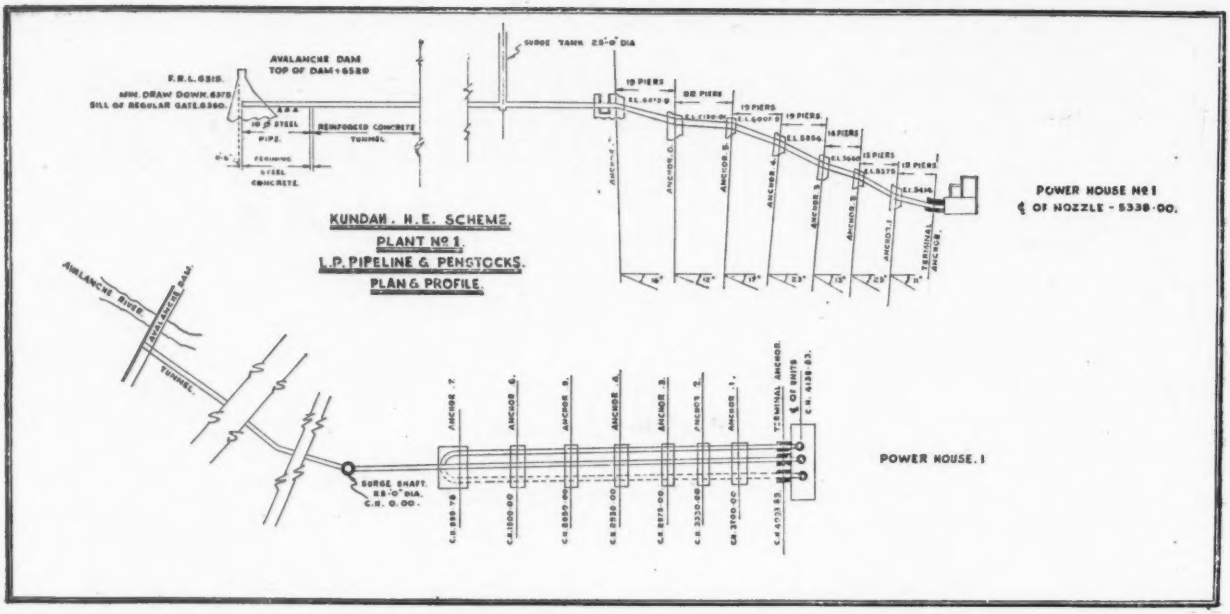
DESIGN OF ANCHORS AND PIERS

The sub-soil particulars at various anchor locations was gathered by putting trial pits. In major portion of the alignment, only ordinary red gravel and hard gravelly soil was met with. Nearer to power house area soft white clay and hard granite rock were met with. With the above particulars the anchor blocks were designed on the assumption that the safe bearing pressure on the soil is not likely to exceed about 1 ton per sq. ft. Also since soft or hard rock was not met even upto 35′- 0″ depth in trial pits, only spread foundation have been provided.

The construction of the substructures of the anchors which could be done without the use of the haulage was taken up first in April 1958. The rainy season in July and August affected the work to a certain extent. However with concentrated attention, concreting of the substructures of most of the anchors was completed by the end of December 1958.

Tunnel 1





The penstock pipes are supplied by Canada in 23′-9″ lengths and the spacing of saddle piers adopted is single pipe length.

STEEL PENSTOCK PIPES

The penstock pipes are made of special type of high tensile steel U.S.T. 1 steel with an yield strength of 90,000 lbs. per square inch. This is the first time such a type of steel is used in India. This has three times the yield strength of ordinary steel and readily weldable without pre-heating or stress relieving with an atmosphere corrosive resistance of 4 times that of carbon steel. The thickness of the pipe varies from 5/16″ to 3/8″ between anchors 7 and 5, 3/8″ to 7/16″ between anchors 5 and 4, 7/16 to 1/2″ between anchors 4 and 2 and 1/2″ to 9/16″ from anchor 2 to terminal anchor.

The use of special quality steel has reduced the total weight of penstocks. The reduction in weight and the change of diameter is taken advantage of to conserve shipping space by telescoping the pipes, with consequent economies in shipping space, freight, handling etc.

TANSPORT OF PIPES TO WORK SITE

The penstock pipes started arriving in November 1957. Unloading from railway trucks and loading on to road trucks at Karamadai for transport to work site was done with the help of a 25 ton gantry and 22 R.B. crane. A 10 ton Hitachi power winch was erected at anchor 6 for hauling down the penstock pipes to the respective locations from anchor 6 to 4. Another winch was erected at anchor 4 for the transport of pipes from anchor 4 to 1. The weight of steel penstock transported for the two lines is about 920 tons.

ERECTION OF PENSTOCKS

Before the erection of penstock pipe the following works were carried out :—

(*i*) Getting ready the sub-structure of all anchors and piers.
(*ii*) Keeping ready all the machines and accessories for welding.
(*iii*) Erection of bends at anchors and concreting the superstructure of anchors

After the above works were carried out, the erection of the pipes was taken up. The procedure followed is described in the following paras.

The civil engineers establish bench marks and give the alignment lines. Bench marks (concrete pads) giving both centre lines and elevations were placed both under the U. S. and D. S. ends of each bend. After this the mechanical section located the bend in position using the points as given above. After determining the centre line of the bend, it was placed on the line of the bench mark and at the correct elevation and L. S. After the erection of the bend was completed the Canadian engineer checked the location of the centre of the bend, its elevation, alignment etc. After Canadian engineer has satisfied himself that the bend has been set correctly, storing up of the bend was done and the holding down strap was secured for concreting.

During concreting, checks were carried to ensure against the movement of the bend. After the completion of bend concreting and after the setting time, the department carried out the erection of the U. S. straight section pipes. Then the department took up sub-assembly and correct aligning of the pipe joints for field welding by Davie's welders.

[*Continued on page* 41

Power Projects Proposed in the Third Plan

By V. P. APPADURAI

Industrial development is growing fast in the country both in the public and private sectors and this is far outreaching power development. This has been the case in almost all the States in the recent years.

In Madras State during the third Plan period large scale industrial development requiring large blocks of power has been programmed. More important of these are the aluminium industry to be established at Mettur, the raw film factory to be erected at Ootacamund and the iron industry to be set up at Salem District utilising the Neyveli lignite and the iron ore available in the Salem District. A load forecast was prepared by the working group appointed by the Government taking into consideration the licenses for industries already issued and the schemes recommended in the recent report of the Techno Economic Survey of the Madras State conducted by the National Council of Applied Economic Research. Load due to normal expansion of the existing system and the load due to the additional villages that will be benefited during the third Plan were added to these to arrive at the requirements. According to this forecast the demand will rise to 891,000 kW at the end of the second Plan period and to 1448,000 kW at the end of the third Plan period.

The schemes drawn up for implementation during the third Plan to meet this ever-increasing demand for power are estimated to cost. Rs. 133.21 crores as compared to the outlay of Rs. 71.45 crores estimated for the second Plan schemes. The outlay for the first Plan schemes was Rs. 30.68 crores.

POWER PROJECTS

The projects included in the third Plan together with the physical targets are given in table. 1.

Sl. No. Name of project.	*Estimated outlay in lakhs of Rs.*	*Benefits. Installed capacity in MW.*
A. Continuing Schemes.		
1. Periyar Hydro Electric scheme (Stage I)	232	
2. Kundah Hydro Electric scheme (stage I and II)	248	
3. Sandynallah Reservoir Scheme.	28	
B. New Schemes		
4. Mettur Tunnel Scheme Ist Stage.	599	100 MW
5. Kundah Hydro Electric scheme III & IV Stage.	2281	240 MW
6. Periyar Hydro Electric scheme II Stage.	95	35 MW
7. Periyar Pumping Scheme.	62	By implementation of this scheme an addl. 44 million units can be generated at Periyar.
8. Annamalai Hydro Electric scheme (Parambikulam project).	599	95 MW
9. New Thermal Station (Preferably at Neyveli).	2250	200 MW
10. Transmission and Distribution project.	5731	supply to be extended to 800 villages.
11. Improvements to existing power houses Transmission lines and substations.:	700	
12. Investigation of new schemes.	22	
13. Housing scheme for the employees of the Board.	100	
14. Acquisition of Electrical undertakings.	425	
Total	13,332	

CAPITAL OUTLAY AND FOREIGN EXCHANGE

The capital outlay of Rs. 133.32 crores proposed is modest as compared with the national outlay of Rs. 1230 crores envisaged during the third Plan for doubling the installed capacity from 6.4 million kW to 12.8 million kW. The approximate foreign exchange component is about Rs. 43.6 crores while that for the power projects all over the country is estimated at Rs. 300 crores.

HYDRO ELECTRIC PROJECTS

Mettur Tunnel Scheme

The Mettur Tunnel scheme is to utilise the irrigation discharge of 20,000 cusecs at Mettur Dam to develop seasonal power for about 7 months from July to January every year. During this period the storages in the Kundah and Pykara Basin will be conserved to the extent necessary for utilisation in the summer months for firming up the Mettur power. Based on discussions with the Central Water and Power Commission the scheme will be developed in two stages. The first stage which involves the construction of a power house with an installed capacity of 100 MW in two units and utilising 10,000 cusecs will be completed during the third Plan period. The civil engineering works will be completed for both the stages so that later on two more units can be added. The first stage on completion will add to the grid an energy potential of 385 million units.

The scheme has been approved by the Planning Commission and as a special case they have agreed to the commencement of the preliminary works during 1960-61 viz. the last year of the second Plan period.

Kundah H. E. Scheme : III Stage

A total fall of 5359 ft. is available for power generation at Kundah of which the present phase under construction utilises a drop of about 3647 ft. and the third stage extensions is to utilise the balance drop of 1712 and also collecting the water of nearby and enroute rivers. The fall is proposed to be developed in two more power stations, the third power station with an installed capacity of 120,000 kW in three units and the fourth power station with an installed capacity of 50,000 kW in two units. In addition a third unit at plant No. I and a fifth unit at plant No. 2 (now under construction) besides an auxiliary station to utilise the fall between the Upper Bhavani and Avalanche reservoirs with an installed capacity of 15,000 kW are also envisaged. The total installed capacity that will be added during this stage is 240,000 kW. Thus on completion the Kundah Hydro Electric scheme will have an installed capacity of 420,000 kW. The energy potential of this scheme will be 1803 million kWh per annum.

The scheme has been investigated and the report is now under scrutiny by the C. W. & P. C. and the Planning Commission.

Parambikulam Hydro Electric Scheme. (Annamalai Hydro Electric Scheme)

This project envisages the construction of two power stations one in the Parambikulam valley utilising the waters diverted from Nirar and the surplus waters available from Sholiar over and above the requirements of Kerala State at their Sholiar Power house and another at Sarkarpatty utilising the tail race waters of the first power station and regulated flows from the Parambikulam, Tunakadau and Tekkadi rivers. The first power station (called Sholiar) will have an installed capacity of 70,000 kW in two units and Sarkarpatty power station will have a single generating unit of 25,000 kW. Detailed investigation of the scheme is currently under progress.

Periyar Pumping Scheme

The scheme is for utilising, by pumping the dead storage available in the Periyar lake, for increased power production during non-irrigation period. This will level up the seasonal nature of power production at Periyar and will also increase the quantity of water available for irrigation from 26190 M. cft to 29450 M. cft. An additional 43.5 million units can be generated during summer months in the power station.

Periyar II Stage Extensions

This provides for the installation of one more 35000 kW unit at the recently commissioned Periyar Power Station to increase the installed capacity from 105,000 kW to 140,000 kW.

The pumping scheme and the second stage extensions are awaiting the clearance by the Projects Advisory Committee of Government of India.

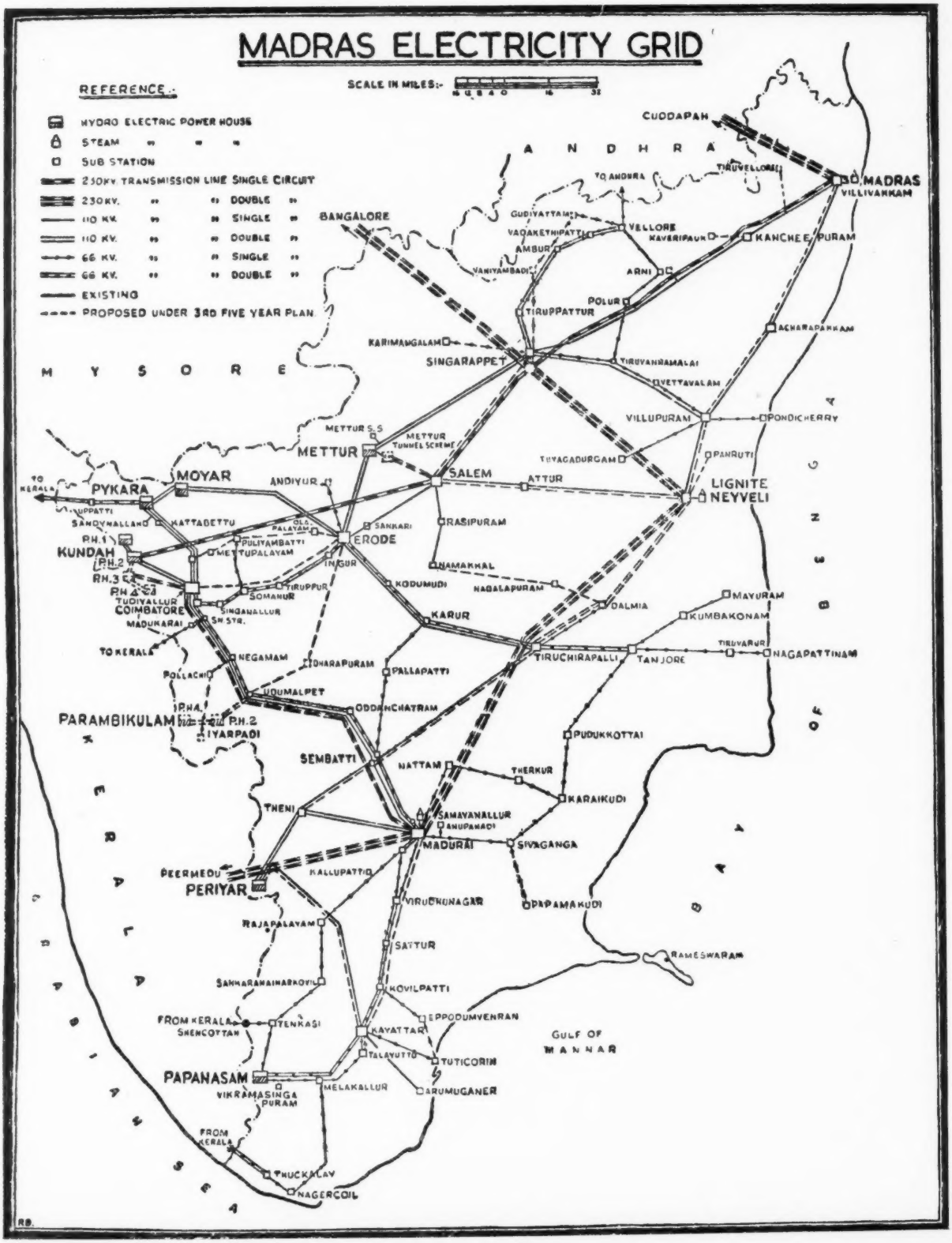
THERMAL PROJECT

At present we have only two thermal stations one at Madras and the other at Samayanallur. Coal for these stations come from Bengal and Bihar and there is considerable difficulty in transport of coal apart from the continually rising cost of coal. It was believed that there was no coal deposits in Madras State and therefore the power development in the earlier years was mainly confined to the development of hydro resources. With the present day cost of coal, the cost of thermal power is nearly thrice as that of hydro power. Now that lignite has been located in Neyveli, South Arcot District it is proposed to utilise it for power generation. The Neyveli Lignite Corporation which is installing a power station have promised to give power to an extent of 159,000 kW beyond the second Plan period. This quantum of thermal power will not be adequate to firm up the hydro generation and it was therefore proposed to set up a new thermal station of 200,000 kW to meet the needs of the State. In view of the difficulty in transport of coal to the South it was decided that the obious location is Neyveli (at the pit head). As the Neyveli Lignite Corporation will be having a power station it was further decided to request them to install additional generating units to the extent of 200,000 kW and release this power in full to the Madras State; in the alternative the Corporation is to supply enough raw lignite for a separate thermal station to be started as a part of the Madras Grid.

ENERGY AND POWER POTENTIAL OF MADRAS GRID

The installed capacity of the hydro stations by the end of 1965-66 will be 92,000 kW with an annual energy potential of 4285 million kWh; the total energy of the Grid will be 7280 million kWh per annum inclusive of the energy available from the thermal stations and the power to be purchased from the Neyveli

MADRAS ELECTRICITY GRID



RD.

Lignite Corporation. The total capacity of the Grid will be 1400,000 kW inclusive of the 359,000 kW to be obtained from Neyveli Lignite Corporation.

TRANSMISSION

The more important of the transmission lines of voltage 66 kV. and above programmed can be seen from the Grid map. Perhaps the most important feature of the transmission scheme for the third Plan is the formation of 220 kV. Super Grid under contemplation. This will facilitate effective utilisation of power within the State and also efficient interchange of power between Madras and its neighbouring States. The Super Grid will necessitate the construction of 220 kV. D. C. line from Neyveli to Singarapet, Neyveli to Madurai and a 220 k.V. S. C. line from Tudiyalur to Kundah. It is also proposed to interconnect Madras and Mysore and Madras and Kerala by 220 KV transmission lines. The interconnection between Madras and Andhra is to be taken up later. Initially it is proposed to consider the possibility of interchange of 50,000 kW between Madras and Mysore and an equal amount between Madras and Kerala. Singarapet and Madurai will form the linking points with Bangalore (Mysore State) and Peermedu (Kerala State) respectively.

CONCLUSION

Even after the third Plan schemes are completed Madras will still be in deficit of power. The existing hydro cum thermal grid will have to be suitably extended to meet further needs. The economical schemes within the State and the inter-State schemes should be taken up and completed. Mysore and Kerala States which are liberally endowed by nature with hydro electric sites when fully developed may be able to spare a small quantum of power initially. This will not be adequate to meet our needs. Further with the growth of industrial development in their own States, they may need additional power and consequently be forced to reduce their quantum of export to Madras if not cut off altogether. Under these circumstances setting up an atomic plant of 250,000 kW capacity in Madras State is imperative, especially as the assured power supply resulting therefrom will give a fillip to the establishment of new industries and expansion of the existing units with the concomittant increase in productivity and standard of living.

KUNDAH HYDRO-ELECTRIC SCHEME

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[*Continued from page 22*

Kundah Hydro Electric Scheme

FURTHER DEVELOPMENT

The demand for power in the State is ever increasing, several new industries are being planned all over the State. A recent forecast prepared taking into account all the above, indicates that the power requirements will be of the order of 7,27,000 kW in 1960-61, and 14,48,000 kW in 1965-66. To meet this ever-increasing demand, new power resources are being tapped. Kundah III stage extensions is one among the new schemes proposed for execution during the third Plan period.

A total fall of 5359 ft. is available for power generation of which the present phase under construction utilise a drop of about 3647 ft. and the III stage extensions is to utilise the balance drop of 1712 ft. and also collecting the water of nearby and enroute rivers. This fall is proposed to be developed in two power stations, the third power station with an installed capacity of 120,000 kW in three units and the fourth power station with an installed capacity of 50,000 kW in two units. In addition a third unit at Plant I and a fifth unit at Plant II (now under construction) besides an auxiliary station to utilise the fall between the Upper Bhavani and Avalanche reservoirs with an installed capacity of 15,000 kW are also envisaged. The total installed capacity that will be added is 240,000 kW. The scheme estimated to cost Rs. 22.81 crores has been submitted for sanction. The total installed capacity will therefore be 420,000 kW after the third stage is completed.

ESTIMATED COST AND FINANCIAL RESULTS

The estimated cost of the initial phase of the scheme is Rs. 35.44 crores including the transmission lines and substations. This is expected to yield a return of 4.5% from the tenth year of operation.

It is a matter of pride to note that this mammoth scheme with the work sites extended over several miles, was completed in a record time of a little over 3½ years which is an achievement in the history of the department. This was possible mainly due to co-operation of all engineers and staff connected with the project both in Canada and in India including Canadian manufacturers who advanced their schedule of delivery of equipments in a few instances. By judicious planning economic execution, careful supervision and control of expenditure, at every stage, it has been possible to effect a saving of about 2.5 crores of rupees. This is another achievement worth recording.

[*Continued from page 40*

Erection of Penstock No. 1

All necessary clip angle for bolting up cleats, shims and wedges necessary to sub-assemble and align the pipes were placed in position and welded by the departmental erectors and welders with the assistance of a Davie's plateman.

When sub-assembly work was over the Davie's welding superintendent or his representative inspected the joint and after approval by him, the welding was commenced. In view of the special type of steel, Canadian welders who have experience in this special type of welding were being employed for field welding of pipes.

The welding done was radiographed after completion of each welding operation. Only the manifold was longitudinally welded in field. All other welds were circumferential which were spot radiographed as follows:—

(*A*) All inter-sections of weld
(*B*) At least 4 spots of each circumferential joints placed equidistant.

Sections of welds shown by radiography to have any defects or imperfection were repaired and radiogrphed and then the joints were passed.

To avoid any side movement due to solar effects the following precautions were taken:—

(*a*) The checking of the pipe for line and elevation, the tack welding of the joint and the pouring of the piers were done before 10 A.M. or after 3.P.M. This is imperative in lower reaches.

(*b*) The pouring of the piers should follow the pipe erection as closely as possible, say a maximum of two pipe length.

The erection of the penstock pipes was commenced at anchor 4 of 'A' line of plant I on 6th October 1958 and lines were completed in December 1959.

The 'A' line after erection was tested as per Davie's hydro static pressure (i. e. about twice static head), reach by reach and also cumulatively. The line was found to be O. K. in all respects.

During tests, precautions were taken to provide adequate number of air valves at the upstream end of the pipe. The purpose of the air valves was to admit adequate quantity of air into the penstock to prevent vacuum being created in the pipe in case of failure of any welded joint and consequent rapid draining of the pipe.

Technical Notes & News

Mobile Cranes Bring Costs Down

For handling loads of up to 3.5 tons the mobile crane having this capacity is specially suitable. This crane is powered by an air-cooled two-cylinder diesel engine of 31 H. P. The travelling speed is up to 19.8 km/h (12.3. m.p.h.). The crane is capable of climbing up, with load, gradients of ap-. prox. 20%. The angle of slew for the jib 60°. The low overall height of the vehicle of 2.30 m (7′7″) permits passing through low-headroom doors; the excellent manoeuvrability and reduced width enables the crane to work also in narrow alleys. The basic outreach with the jib in the horizontal position is 3.5m (11′16″) and can be telescopically extended to 5,0 m. (16′5″). All handling movements are hydraulically operated.

The mobile crane for a capacity of 7 and 9 tons respectively is of similar design and powered by an aircooled four-cylinder diesel engine with an output of 48 H.P With a 4-speed gear-box a travelling speed of 18.8 km/h (11.6 m.p.h.) is obtained. The slewing range of the jib is 360°, the overall width of the vehicle is 2.5m (8′). For road travel the jib can be aligned to point to the rear, so that the overall length of the crane (7.72m=25′5″) does not exceed that of a road truck.

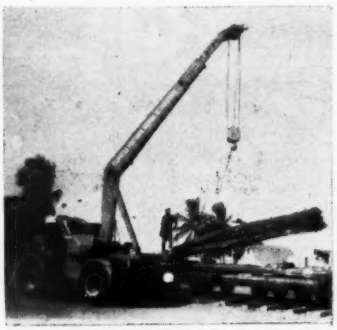
The jib of this type of mobile crane has a basic outreach of 5m (16′5″) which can be lengthened telescopically to 8 m (26′3″) or, in the case of a special design to 10m (32′10″). For erection work a special jib is available affording a height of hook above ground level of about. 15 M (50′). Special accessories such as lifting magnet installation, grab outfit for one-or two-rope operation, capstan winch etc. further increase the versatility and adaptability of the crane.

For heavier loads up to 27 tons mobile cranes of excavator design can be supplied which may be alternatively equipped with one or two power units. The travel speeds vary between 20 and 60 kmh (12.5 to 37 m.p.h.), and the cranes can be adapted to work with a grab, face shovel or backhoe attachment, dragline bucket, lifting magnent, and drop pile hammer. Pneumatic control enables easy operation of all handling and travel movements during the whole working day without undue strain on the driver.

As they are equipped with suitable safety devices such as limit switches, load moment limitation etc., the mobile cranes are to a large extent protected against operating errors. The electrical quipment corresponds to that of a truck and can be supplemented by providing working floodlights.

For weather protection either a full vision cab or a roof for the tropics is available. INDMAG PRIVATE LTD. would be glad to provide further particulars.

A mobile crane in action



Giant Crawler

The International Harvester Export Co. of U.S.A. has introduced the new International TD-25 Diesel Tractor—the largest and most powerful crawler ever produced by them. The unit is designed for major earthmoving, logging, pipe line laying, and mining operations. The TD-25, gear drive tractor has a drawbar pull of 46700 lbs. and the torque convertor tractor upto 70000 lbs. It is powered by an International TD-817 turbocharged diesel engine, a six-cylinder four-cycle, direct starting unit developing 230 net horsepower at 1,500 rpm (just 60% of its potential 385 h.p.)

The TD-25 is equipped with large-reservoir track rollers with exclusive cartridge-type seals. These rollers require lubrication only at 1,000-hour intervals.

The heart of the tractor's operating efficiency is IH's exclusive Planet-Power system, which permits turning with controlled power on both tracks, with effortless finger-tip steering. This engineering refinement eliminates power-wasting, "deadtrack drag" in turns, permitting the fully-loaded tractor to turn smoothly whether working up or down grade or on the level. The same system also provides instant power shifting from one speed range to the next, as well as one-hand hydraulic braking.

A complete line of control units, hydraulic or cable controlled blades, and pusher plates is available for the new TD-25—the sixth new crawler introduced by International Harvester within the last year.

The International Harvester Co. manufactures a wide range of earthmoving equipment which is sold and serviced in India by Voltas Limited.

The International TD-25 diesel tractor—the largest and most powerful crawler ever produced by International Harvester. Here is the TD-25 with the D-1 front cable controlled bulldozer blade.

New Caterpillar D6 Tractor

A new "work-styled" D6 Series B Tractor that incorporates major improvements resulting in much greater machine and operator efficiency is now available, according to an announcement by Caterpillar Tractor Co.

Among the major new features are: a completely new, compact engine that gives the tractor 25 per cent greater lugging ability; two new hydraulic control units that are now integrally mounted; a tilt cylinder for special applications; an optional transmission for jobs calling for higher drawbar pounds pull and an all new operator's compartment that is more efficient and comfortable.

Resulting from the latest metallurgical advances, the new engine delivers 93 flywheel horsepower at 1,600 rpm. Extensive research and field testing of the modern design engine shows it to have greater economy and easier servicing in addition to its increased work potential.

The hydraulic control pump and tank are located at the rear of the engine, under the engine hood. This arrangement clears the radiator face and permits greater air flow, which in turn increases the radiator cooling ability. The two new hydraulic controls are the No. 165 and the No. 143.

Both new units deliver constant hydraulic power because the pump is driven off the timing gear train. Also, both units have full-flow hydraulic fluid filtration. A check valve in the pressure line holds the dozer blade in position when the control valve is moved from "hold" position to "raise."

The No. 165 hydraulic control is intended primarily for control of the bulldozer blade. However, its use can be expanded so that it will also control either a tilt cylinder or a tractor-mounted ripper. This is possible by the addition of one internal valve. The addition of another, externally mounted valve makes it possible to control a bulldozer blade, tilt cylinder and ripper with the one hydraulic unit.

The No. 143 hydraulic control can be used for operation of the tilt cylinder on cable controlled bulldozer blades, or for control of the tool bar and the tool bar bulldozer. The tilt cylinder is foot controlled, increasing the ease of operation and encouraging higher production.

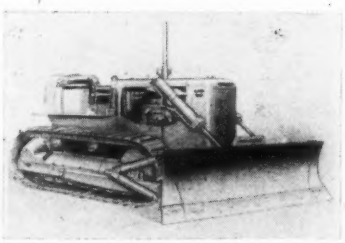
Hydraulic control cylinders are center-mounted, allowing almost twice the bulldozer blade drop below ground level. The standard radiator guard has been strengthened through re-designing and now permits installation of hydraulic or cable bulldozer blades without requiring a special, heavy duty guard.

Increased efficiency is the keynote of the new operator's compartment. Gear shift selector lever and forward-reverse lever are relocated so as to reduce hand travel distance. Also, the seat has been moved six inches forward and is fitted with wide arm rests and side padding. Footrests are relocated, providing more natural work positions. Guages are grouped into a new, console-type panel, making them more easily read and protecting them from damage.

An all-new gasoline starting engine with off-track recoil starter is standard on the D6 Series B Tractor. This new engine develops 15 horsepower. In-seat starting for the gasoline engine is optional and makes use of a 12-volt electric system. Also available as optional equipment is a 24-volt direct electric starting system for the diesel engine. Batteries for both the 12-volt and the 24-volt in-seat starting systems are located beneath the operator's arm rest.

Both the diesel and the gasoline starting engine are equipped with the new, high efficiency dry type air cleaners. The dry type air cleaner on the diesel engine is of a new type, consisting of two filter elements. The main element is easily removable and quickly cleaned with air pressure. A second, safety element provides additional protection to the engine in the event the main filter element receives undetected damage. A top-mounted precleaner removes the majority of all filterable foreign particles with the primary element taking out the remainder. The new air cleaner has a minimum efficiency of 99.8 per cent under all conditions.

New styling and mounting of the new hydraulic unit on the D6 Series B Tractor are easily seen in this model.



Our Contributors

Mr. G. Thirunavukkarasu joined the department during 1936. He served in the different categories in the various power projects of the State such as Papanasam, Pykara Plant Extensions, Machkund and Kundah. He is now Superintending Engineer, Kundah hydro electric scheme from January 1958.

Mr. V. P. Appadurai joined Madras Electricity Department during 1932. He rose to the position of Superintending Engineer of the Technical Branch in 1948 and became Chief Engineer of the Madras Electricity Department in 1954. After the formation of the State Electricity Board in 1957, he is now the Chief Engineer and Technical Member of the Board.

During 1952, he visited U.S.A., Canada, U. K. and the Continent under the Colombo Plan Fellowship Award. During 1956, he went to Canada as a member of the Government of India delegation to finalise the terms of the Colombo Plan Aid for the Kundah hydro electric scheme. He again went to Canada during 1956 to finalise the orders for the Kundah plant and machinery and Germany in 1958 to expedite the despatch of the generating machinery for the Periyar Scheme. He made another visit to Canada during the end of 1958 to inspect the equipments under manufacture for the Kundah Project.

Mr. L. G. Grandy is the Canadian Supervising Engineer at site representing Messrs. Montreal Engineering Co., Ltd., Canada, who are the Consulting Engineers to the Govt. of Canada for the Kundah hydroelectric scheme. He has been associated with this project from the beginning.

Mr. R. M. Thirumalaikolundu joined the department during 1936. After serving in various categories in the different projects of the department such as Papanasam, Pykara Dam, Machkund and Kundah, he became the Superintending Engineer in 1957. He is now the Superintending Engineer, Technical (Civil) in this department.

Mr. M. Kothandaraman is Assistant Engineer (Civil) in the office of the Superintending Engineer, Technical (Civil), Electricity Department, Madras.

Technical Notes & News

[*Continued from page 46*

Operator visibility is improved to the point where the cutting edge of both right and left ends of the dozer blade are visible. The increased visibility is partly attributable to the new, tapered hood as well as to relocation of the new seat.

The D6 Series B Tractor has sufficient fuel capacity for a complete work shift. Fuel tank capacity was increased to 65 gallons from 48 gallons on previous models.

Balance and stability of the machine, and its ability to be worked with heavy, front mounted equipment is improved through use of the new, compact engine. Oscillaton is increased through a new equalizer spring arrangement that "shifts" the center of gravity uphill when operating on sidel slopes. This increases the already great versatility of the machine by making it capable of safely working on steep sideslopes.

The No.6S and No.6A Bulldozer and the No. 6 Tool Bar are available with the new D6 Series B Tractor. The No. 6S blade for the 60-inch guage tractor has been modified to a total width of eight feet, meeting transport requirements. The tilt cylinder on the new D6 is foot controlled.

A fixed drawbar with cast steel brackets and a two position clevis is standard. A swinging drawbar is available as optional equipment.

A large diameter diler is standard on the new D6, with a small idler available as an attachment. Six track rollers are mounted on each frame. All track rollers and the idler as well as the carrier rollers are lifetime lubricated. A hydraulic track adjuster is available as an attachment.

Bevel gear and pinion of the new D6 are improved and have increased capacity because of a coarser pitch. Speeds of the optional transmission match tractor speed and drawbar pounds pull to those most desirable for towed implements in special applications. The optional forward speeds are: 1.9 mph in first gear; 2.8 mph in second gear; 3.4 mph in third gear; 4.3 mph in fourth gear, and 6.0 mph in fifth gear. Reverse speeds are: 2.4 mph in first gear; 3.4 mph in second gear; 4.1 mph in third gear and 5.2 mph in fourth gear.

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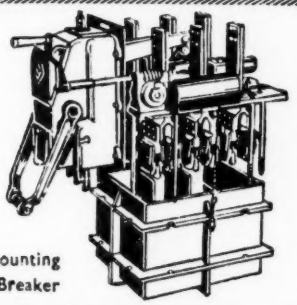

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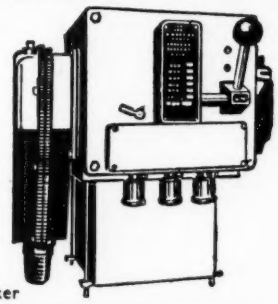

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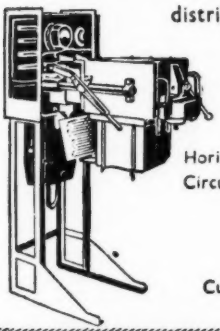

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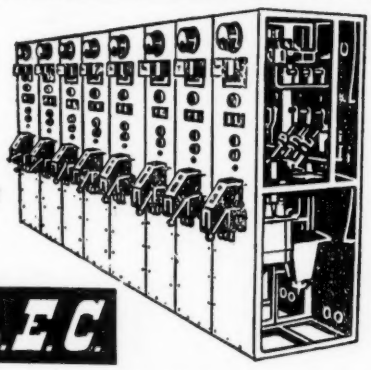

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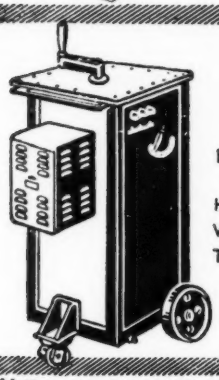

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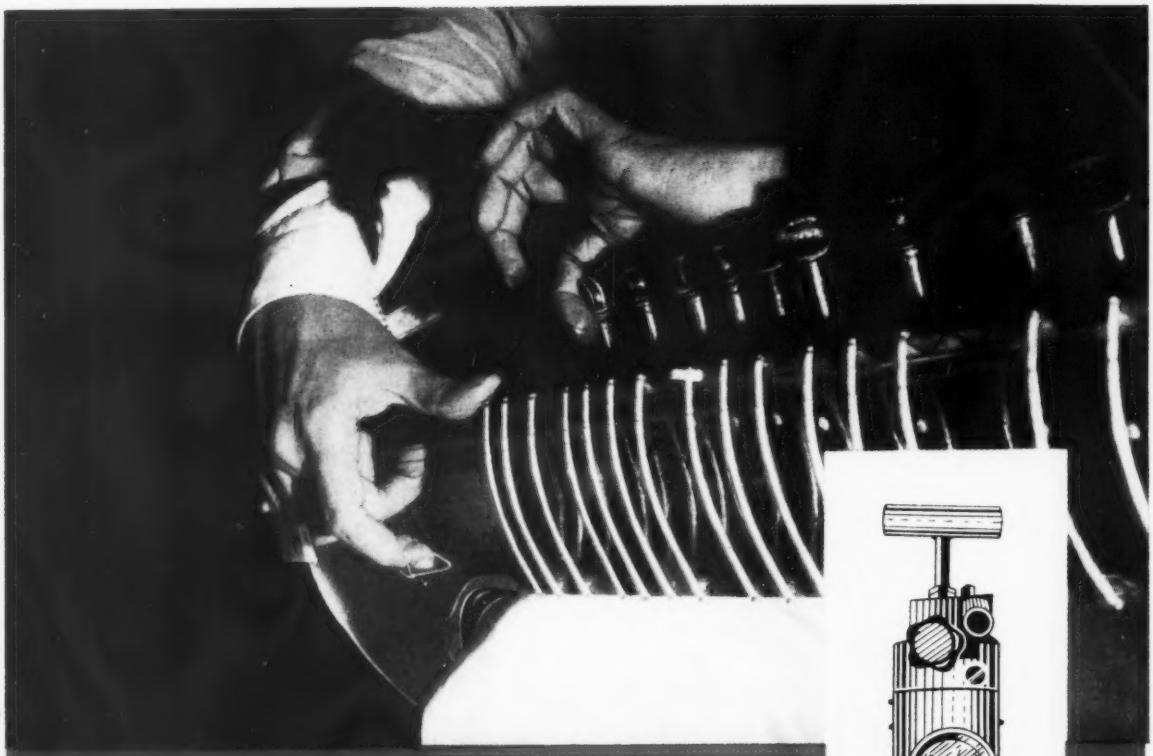

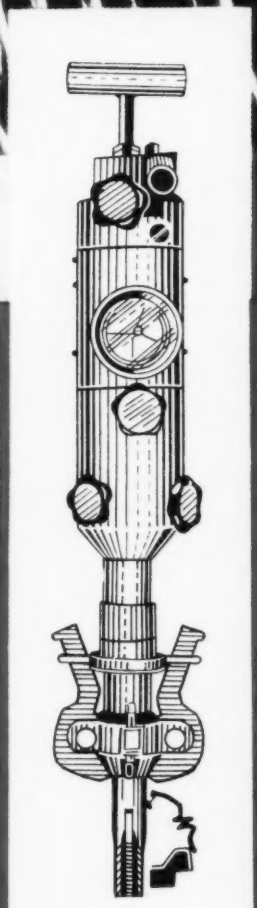

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